CALIFORNIA
AQUATIC INVASIVE SPECIES
MANAGEMENT PLAN

The California Department of Fish and Game

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ACRONYMNS

Acronyms for the agencies and organizations referenced in this management plan:

CeNCOOS	Central and Northern California Ocean Observing System
CSG	California Sea Grant
DBW	California Department of Boating and Waterways
DFG/ OSPR	California Department of Fish and Game /Office of Spill Prevention and Response
DFA	California Department of Food and Agriculture
DPR	California Department of Parks and Recreation
DWR	California Department of Water Resources
ISAC	United States Invasive Species Advisory Committee
ISP	Invasive *Spartina* Project
NOAA	National Oceanic and Atmospheric Administration
OPC	California Ocean Protection Council
OSA	Ocean Science Applications
PBWG	Pacific Ballast Water Group
PSMFC	Pacific States Marine Fisheries Commission
RWQCB	Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCCOOS	Southern California Coastal Ocean Observing System
SLC	California State Lands Commission
SWRCB	State Water Resources Control Board
TRPA	Tahoe Regional Planning Agency
TRCD	Tahoe Resource Conservation District
USDA/ ARS	United States Department of Agriculture /Agricultural Research Service
USDA/ APHIS	United States Department of Agriculture/ /Animal and Plant Health Inspection Service
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

EXECUTIVE SUMMARY

This plan proposes management actions and a rapid response process for addressing aquatic invasive species (AIS) threats to the State of California. It focuses on the non-native algae, crabs, clams, fish, plants and other species that continue to invade California's creeks, wetlands, rivers, bays, and coastal waters.

AIS cause far-reaching environmental and economic impacts. They threaten commercial, industrial, recreational, and agricultural activities by diminishing production; clogging waterways, flood control and irrigation channels; and rendering swimming, fishing, and boating areas unusable. AIS may also harbor parasites and diseases dangerous to the health of humans and native species. They can also disrupt the balance of natural ecosystems by consuming or competing with native plants and animals, alter biogeochemical cycles, and reduce native species diversity.

These invaders from Asia, Europe and abroad are unlike the non-native weeds, trees, or mammals that plague human activites on land because they live in, and/or are spread through, water. The watery resources threatened by AIS are considerable, and central to California's economic and ecological well-being. California's waters include approximately 3,500 miles of coastal waters and estuaries, over 210,000 miles of rivers and streams, over two million acres of freshwater wetlands, lakes, ponds and reservoirs, over 400,000 acres of saline lakes, and more than 22,000 miles of ditches and canals. These aquatic resources provide habitat for marine and freshwater fisheries, aesthetic enjoyment, hydropower, irrigation, municipal and industrial water supplies, and countless recreational and commercial opportunities, including tourism, aquaculture, and other industries.

The broad-scale introduction of species into California waters began with the shipment of tens of thousands of barrels of oysters from the East Coast after the establishment of the transcontinental railway (Barrett 1963). Today, state surveys have identified 604 introduced, or likely introduced, species in California's estuaries.

Among the most problematic AIS that have become established in California are the European green crab, *Carcinus maenas*, which preys on the young of native Dungeness crab, an important commercial fishery; Chinese mitten crab, *Eriocheir sinensis*, which undermines the stability of levees and shorelines with its burrows; and the Asian clam, *Corbula amurensis,* which has altered the food web of the state's largest estuary. A suite of non-native clams, copepods and plants are implicated in the sharp recent decline of endangered Delta smelt. In 2004, the escaped aquarium alga *Caulerpa taxifolia*, which has overrun aquatic ecosystems in the Mediterranean Sea, was found in Southern California. Efforts to eradicate it have cost $7 million to date. Meanwhile, other invasive aquatic plants continue to infest many of California's riparian areas and marshes.

But perhaps even more important are the species that could invade California in the future. For example, the freshwater zebra mussel (*Dreissena polymorpha*) colonizes pipes and constricts the flow of water in equipment. Within twelve years of arriving in North America from Europe in ship ballast water, it had spread to at least 20 U.S. states. Battling the mussel now costs millions every year. Though not yet found in California, it has been intercepted at border inspection stations. If the mussel becomes established in state waters, it could cripple the irrigation network supporting California's $30 billion agriculture industry, as well as the infrastructure that transports drinking water around the state.

The increasing globalization of our economy, and the rapid movement of both people and goods, means that bioinvasions are only likely to increase in California. Transoceanic shipping may be a major source of AIS invaders. The state estimates that about 7.8 million metric tons of ballast water were discharged in California waters in 2004, and in 2005 such discharges reached 9.1 million metric tons (SLC, Pers. Comm. 2006). Hull fouling may rival ballast water discharge as a leading historical cause of harmful AIS introductions. Species such as mussels and anemones can attach themselves to the hulls of vessels or become entangled in nets, anchors, and other gear. They often harbor hitchhikers of their own in the form of barnacles, bryozoans, worms, and sea snails (Takata et al, 2006). They can be introduced to new waterways when dislodged or spawning.

AIS can be transported from place to place via many additional pathways, or vectors. Invasive species can cling to recreational gear, fishing equipment, drilling platforms, and floating debris and docks. They may escape (or are released) from aquaculture packing materials, ornamental ponds, and aquariums into state waters. Shoreline restoration and construction projects, as well as water-based scientific research, move species about as well.

The threat of aquatic invasions poses major challenges to California's aquatic systems managers and aquatic policy makers. A few organisms are capable of multiplying to infest an entire water body, watershed, or bioregion. Resources must be devoted to preventing new introductions as well as to containing existing populations.

California's past efforts to address AIS focused on controlling individual problem species that directly impacted boating, agriculture, and other human activities. More recently, state management has begun to shift toward regulating ballast water discharges, and toward intervention and education among those most likely to be unintentional vectors. State approaches toward AIS control include prevention, eradication, management, and education. However, these activities are not well coordinated throughout the state, do not comprehensively manage established AIS, nor adequately defend against new invasions.

This management plan provides a framework to respond to AIS in California, and protect the biological integrity of California's native plant and animal communities. It targets both marine and freshwater environments and highlights the need for aggressive action and coordination on many fronts. It provides for a more formal multi-agency, multi-interest management structure to allow for the comprehensive assessment of AIS activities. This new decision-making structure will ensure action on high priority activities, improve utilization of scarce state resources, and help identify and bridge gaps in coverage. The plan also outlines the state's first rapid response process for high-risk invaders.

The management plan's primary goal is to minimize the harmful ecological, economic, and human health impacts of aquatic invasive species in California. The plan has eight major objectives:

1) Improve coordination and collaboration among the people, agencies, and activities involved with AIS;
2) Minimize the introduction and spread of AIS into and throughout the waters of California;
3) Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS;
4) Establish systems for rapid response and eradication;
5) Control the spread of invasives, and minimize their impacts on native habitats, listed species and restoration projects;
6) Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California;
7) Increase research on AIS, the economic impacts of invasions, and control options to improve management;
8) Ensure State laws and regulations promote the prevention and control of AIS.

The plan will provide a much-needed blueprint for a coordinated state approach to current and future biological invasions of the California waters.

I. INTRODUCTION

What are Invasive Species?

Federal law defines “invasive species” as a species that is non-native to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. In other literature and in legislation, such invaders are also sometimes referred to as “nuisance” species.

Invasive species are different by definition than non-native, non-indigenous, alien or exotic species -- terms that refer to species that humans have intentionally or unintentionally imported to areas outside their native range. Species that spread widely beyond the location of initial establishment, become locally abundant, or spread into natural areas, are “invasive.” The definition of “invasive,” therefore, depends on time and spatial scales (Lodge et al, 2006).

This management plan focuses on ***aquatic*** **i**nvasive species -- alga, crabs, clams, fish, plants and other invaders to California’s creeks, wetlands, rivers, bays and coastal waters. Aquatic invasive species (AIS) threaten the diversity and abundance of native species and natural communities, the ecological stability and water quality of infested waters, and the commercial, agricultural, aquacultural, and recreational activities dependent on these waters. The economic consequences of AIS impacts can be substantial, from decreased productivity of commercial fisheries, to lowered property values and the expenditure of billions of dollars to alleviate AIS impacts in water bodies after they have already become infested (Pimentel et al. 2000).

Geographic Scope

This report proposes management actions and an aquatic invasive species response plan for the State of California. The diversity of California waters is extensive, ranging from the rich coastal waters and estuaries of the Pacific Ocean (approximately 3,500 miles of tidal shoreline), to over 210,000 miles of rivers and streams, over two million acres of freshwater wetlands, lakes, ponds and reservoirs, over 400,000 acres of saline lakes, and more than 22,000 miles of ditches and canals (RF3 computerized database; USGS Digital Line Graph traces; SWRCB’s 2002 WBS database). These diverse aquatic resources provide habitat for marine and freshwater fisheries, aesthetic enjoyment, hydropower, irrigation, municipal and industrial water supplies, and countless recreational and commercial opportunities, including aquaculture, tourism, and other industries.

The authorities and programs outlined in this plan are generally limited to the political boundaries of California. However, it is recognized that there is a need for interstate and international cooperation to prevent the introduction and spread of AIS. The plan prescribes increased coordination with all Western states, as water delivery systems and rivers often cross state boundaries, as well as with Mexico and Canada.

History & Impacts of Invasions

The introduction of non-native species into the United States has been occurring for centuries, probably beginning with the introduction of human diseases and pests as a result of European settlement. The broad scale introduction of species into California waters most clearly begins with the shipment of tens of thousands of barrels of oysters from the east coast after the establishment of the transcontinental railway (Barrett 1963). The huge influx of settlers, the establishment of maritime commerce and a multitude of other human activities through the 1900s contributed to continued invasions. Today, nearly 250 non-native species occupy the San Francisco Bay-Delta alone. The rate at which AIS are becoming established in San Francisco Bay has increased from an average of one new species every 55 weeks prior to 1960, to one new species every 14 weeks between 1961 and 1995 (Cohen and Carlton 1998). According to the most recently available data, researchers identified 604 introduced, or likely introduced, species in California estuarine waters (DFG/OSPR 2001 – see also Figure 1). The increasing globalization of our economy and with it, the rapid movement of both people and goods makes preventing additional AIS invasions a daunting challenge.

The impacts of AIS can be far-reaching both environmentally and economically. They can significantly disrupt the balance of natural ecosystems by consuming or competing with native plants and animals, altering biogeochemical cycles, and reducing diversity of native species. AIS can also threaten commercial, industrial, recreational, and agricultural activities by disrupting fisheries and agricultural production; clogging waterways, flood control and irrigation channels, and intake pipes; and rendering swimming, fishing, and boating areas unusable. They may also harbor parasites and diseases that could potentially be disastrous to both native species and human health. A recent study of ballast water collected from vessels entering the Chesapeake Bay found that 14 of the 15 vessels sampled contained a strain of cholera never before identified in the U.S. (Ruiz et al. 2000).

Those invaders that directly harm human health or important crops are those Americans are most familiar with: sudden oak death, the Mediterranean fruit fly, West Nile virus, SARS, HIV and the avian flu, among others. Invaders that harm natural ecosystems have historically received less attention and response, as their impacts often appear less dire.

In the San Francisco Bay-Delta region, AIS have resulted in extensive economic and ecological damage (Cohen and Carlton 1995). Some of the most problematic AIS that have become established in California include: the European green crab, *Carcinus maenas*, which preys on the young of native

Dungeness crab, an important commercial fishery; Chinese mitten crab, *Eriocheir sinensis*, which burrows into levees and shorelines, undermining stability; and the Asian clam, *Corbula amurensis,* which has changed the structure of a major estuarine food web.

In the last decade, one introduction of major concern in southern California, the escaped aquarium plan *Caulerpa taxifolia*, was the subject to intense eradication efforts. Uncontrolled, *Caulerpa* soon dominates native vegetation and contains toxins distasteful to native marine species.

Invasive plants that are taking over many of California's riparian areas and fresh and salt-water marshes include smooth cordgrass and its hybrids, *Spartina alterniflora* x *S. foliosa*, giant reed, *Arundo donax*, and purple loosestrife, *Lythrum salicaria*. Non-native freshwater macrophytes, such as Brazilian elodea, *Egeria densa* and water hyacinth, *Eichhornia crassipes*, have become established in the Delta, and Eurasian watermilfoil, *Myriophyllum spicatum* infests areas of one of the state's most popular inland bodies of water, Lake Tahoe. (For more information on many of these species see the examples and case studies in Chapters IV & V.)

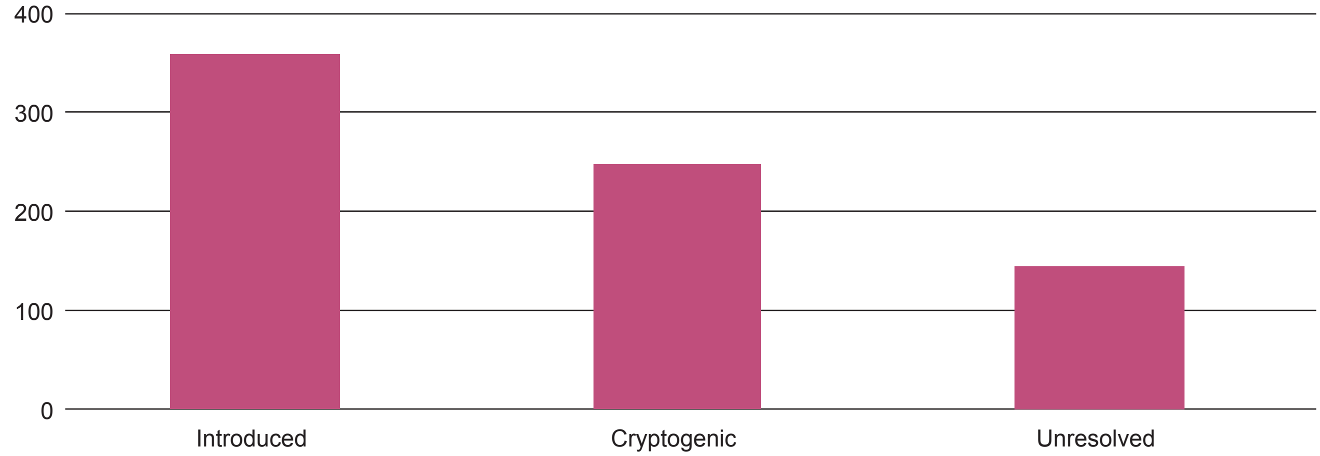
Perhaps the most important issue is not the species that have already invaded, but those that might invade in the future. It is extremely difficult to predict the impacts that AIS may have on natural resources, the economy, and human health and infrastructure. The notoriously invasive freshwater zebra mussel (*Dreissena polymorpha*) was transported to North America from Europe in the ballast water of transoceanic ships. It was first discovered in Lake St. Clair in 1988 and within 12 years zebra mussels inhabited the waters of at least 20 states in the U.S. -- colonizing pipes, constricting flow and thereby reducing water intake for heat exchangers, condensers, fire fighting equipment, and air conditioning and cooling systems. Battling the mussel is costing millions every year. The zebra mussel has yet to be documented in California, but has been detected at border inspection stations. Based on the damage caused in the Great Lakes region, zebra mussels could seriously threaten the entire irrigation network that supports California's $30 billion agriculture industry, as well as the canal system that transports drinking water for millions of residents in southern California.

Bioinvasions of California are likely to grow, as global movements of goods and services continue to increase. In the United States, the number of non-native plant pathogens, insects, and mollusks discovered since 1920 strongly correlates with importation of goods over the same time period, and is forecast to increase by 16-24% over the next 20 years. The movement of goods and AIS into and within California is not only taking place via transoceanic ships, but also via other vectors such as aquaculture, the aquarium trade, the bait industry, recreational activities, biological research, environmental restoration projects, and even freshwater deliveries up and down the state's pipelines and canals.

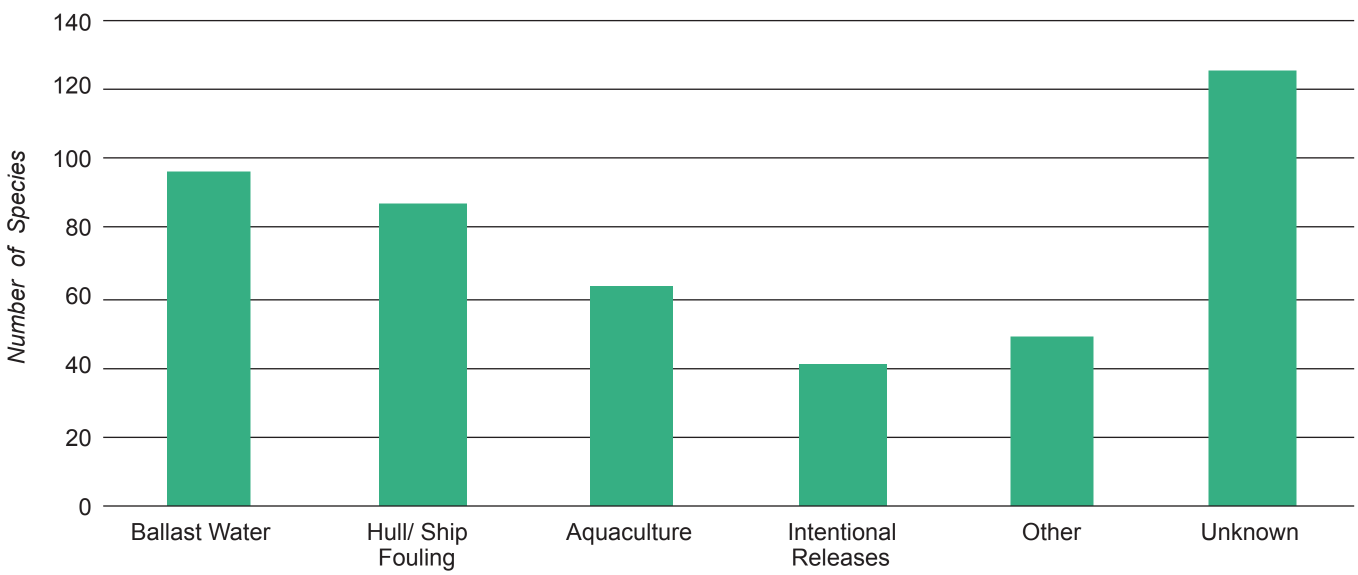
Figure 1: Non-Indigenous Species Surveys from California Harbors & Bays

Numbers of non-indigenous taxa in coastal California waters by introduction status category.

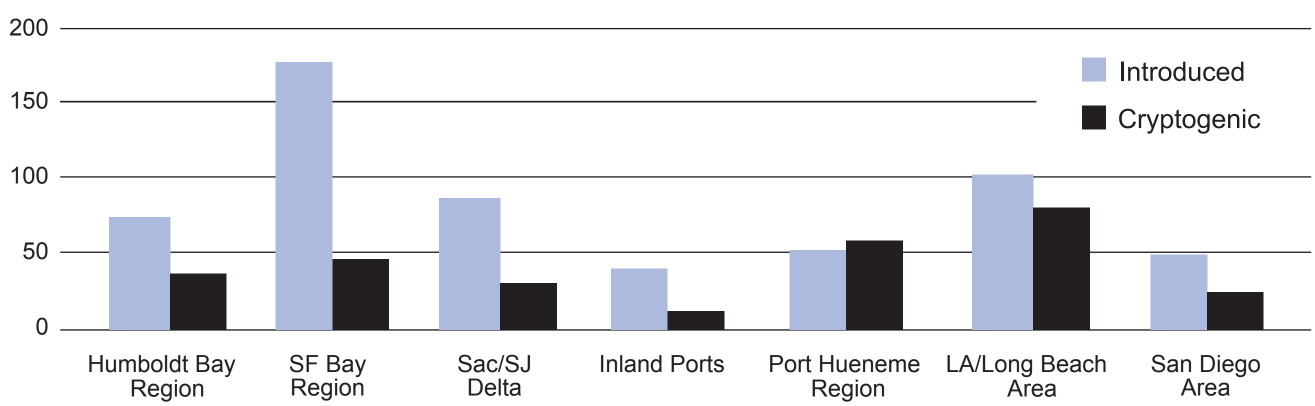
Cryptogenic = neither demonstrably native or introduced.
Unresolved = organisms not able to be identified to the species level, therefore uncertain if native or introduced.



Number of non-indigenous taxa in coastal California waters by vector.



Number of non-indigenous taxa in 7 major ports of California.



This survey only includes harbors, bays, and the Delta (up to Sacramento and Stockton). Outer coastal waters and inland waters are not included.
Source: A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California, CA Dept. of Fish & Game, 2002. For more up-to-date info and new outercoastal data see www.dfg.ca.gov/ospr/organizational/scientific/exotic/MISMP.htm

As the world's largest economy and home to many of the world's richest ecosystems, the U.S. is particularly vulnerable to additional biological invasions (Lodge et al., 2006). California, as a Pacific Coast trade hub, immigration and recreation destination, and major engine of the American economy, will be equally vulnerable.

Figure 1: Nonindigenous Species Surveys from California Harbors and Bays

Benefits of Statewide Plan

The problem of aquatic invasions poses unique challenges to California's aquatic systems managers, as well as to those developing policies affecting aquatic environments. Unlike other sources of pollution, established populations of aquatic invaders can reproduce and spread. As a result, resources must be devoted to both prevention of new introductions and to the control of existing ones. The introduction of only a few organisms or, in the case of aquatic plants and algae, a tiny portion of an organism, can result in the infestation of an entire water body, watershed, or bioregion. These introductions can occur through any number of transport vectors, further complicating preventative measures.

California's past efforts to address AIS focused on control of those species that most directly impacted boating, agriculture and other human activities. More recently, California's focus has shifted toward prevention with programs addressing plant pests and the establishment of the state's ballast water management program. Current AIS activities target prevention, eradication, management, and education. However, these activities are not well coordinated throughout the state, and are not comprehensively managing current established AIS, nor are these programs adequately preparing for new invasions. The vital importance of California's aquatic resources requires the creation of a more comprehensive plan to address these concerns.

This management plan provides a framework for responding to AIS in California, and for protecting the biological integrity of California's waters and native plant and animal communities. It targets both marine and freshwater environments and highlights the need for aggressive action on many fronts. It also meets requirements to develop a statewide Nonindigenous Aquatic Nuisance Species Management Plans under Section 1204 of the Aquatic Nuisance Prevention and Control Act of 1990 (amended as the National Invasive Species Act of 1996). This Act authorizes a 75:25 federal to state match of funds required to achieve objectives and actions outlined in plans approved by the federal Aquatic Nuisance Species Task Force (ANSTF, also established by the 1990 Act). In developing this plan, the State of California has closely followed the *Guidance for State and Interstate Aquatic Nuisance Species Management Plans* developed by the ANSTF (2000). Suggested actions contained in the Western Regional Panel's *Recommendations on State Actions to Improve Our*

Regional Capacity for Managing Aquatic Invasive Species (revised June 2003) were also incorporated.

California Plan Goal & Objectives

The goal of the California Aquatic Invasive Species Management Plan is to minimize the harmful ecological, economic, and human health impacts of aquatic invasive species in California.

To assist in attaining this goal, eight major objectives have been identified:

1) Improve coordination and collaboration among the people, agencies, and activities involved with AIS;
2) Minimize the introduction and spread of AIS into and throughout the waters of California;
3) Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS;
4) Establish systems for rapid response and eradication;
5) Control the spread of invasives, and minimize their impacts on native habitats, listed species and restoration projects;
6) Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California;
7) Increase research on AIS, the economic impacts of invasions, and control options to improve management;
8) Ensure State laws and regulations promote the prevention and control of AIS.

Each objective is supported by a series of strategic actions with the lead agencies identified, and costs included where appropriate. Detailed actions can be found in Chapter VI: Management Actions, Strategies and Objectives, and Chapter VII: Priorities & Implementation Table.

The plan goal, objectives, strategies, and specific actions were developed with input from a series of stakeholder scoping meetings, inter-agency staff communications, and public workshops held in 2002 and 2006. These meetings, as well as many individual conversations and extensive review played a role in making the plan as comprehensive and responsive to AIS issues in California as possible.

II. AIS ENVIRONMENTAL & ECONOMIC IMPACTS

California currently faces a variety of significant and lasting impacts from aquatic invaders in both fresh and coastal waters. In general, these include:

- Reduced diversity and abundance of native plants and animals (due to competition, predation, genetic dilution, smothering and loss of habitat to invasive species).
- Degradation of wildlife habitat.
- Stresses on rare, threatened, and endangered species.
- Alteration of the native food web and declines in productivity.
- Changes in biogeochemical cycles (including nutrient cycling and energy flow).
- Losses in fisheries production.
- Impairment of recreational uses such as swimming, boating, diving and fishing.
- Impairment of agricultural infrastructure such as irrigation canals.
- Impairment of water delivery systems.
- Degradation of water quality.
- Threats to public health and safety (via parasites and disease).
- Diminished property values.
- Loss of coastal infrastructure due to fouling and boring organisms.
- Shoreline, bank, and levee erosion and destabilization.
- Increased costs to business, agriculture, landowners and government of invasive pest control, treatment and clean up.

Environmental Impacts

In terms of ecological impacts, the introduction of invasive species is thought to be second only to habitat loss in contributing to declining native biodiversity throughout the United States. Nationwide, nonnative species have contributed to 68% of the fish extinctions in the past 100 years, and the decline of 70% of the fish species listed in the Endangered Species Act (Wilcove et al. 1998).

California has been invaded by many aquatic plants and animals, which have altered native ecosystems and taken a toll on recreation, commercial fishing and sensitive native species (i.e. species that are listed or otherwise considered rare or declining).

The following are just a few examples of ecological impacts associated with AIS:

- **The European green crab**, *Carcinus maenas,* likely arrived in seaweed packed with bait worms shipped from the Atlantic to the Pacific Coast. They were first detected on the West Coast in San Francisco Bay in the late 1980s. By 1996 the crab had spread along 300 miles of coastal California (Lafferty and Kuris, 1996). Green crabs may prey upon juvenile Dungeness crabs as well as cultured oysters, clams, and mussels. Clam and native shore crab populations in California have dropped significantly since the arrival of the green crab (Sea Grant 1998). Densities of native clams and shore crabs showed a five to ten-fold decline within three years of the green crab's arrival (Grosholz et al. 2000).
- **Giant Reed,** *Arundo donax*, is a native to the Mediterranean and tropical Asia. In California, it was planted as early as the late 1700s as a windbreak, and for erosion control in flood channels. *Arundo* grows in thick, bamboo-like stands that can reach a height of 30 feet. Its monotypic growth displaces native vegetation, increases flooding and siltation, increases water loss from underground aquifers, and increases the susceptibility of riparian areas to fire. Despite its sizable height, it does little to shade in-stream habitat. The higher resulting water temperatures harm aquatic wildlife, including protected frogs, turtles and fish (see also Appendix D, Team Arundo).
- **Asian Clam,** *Corbula amurensis,* was introduced into the San Francisco Bay via ballast water discharge and first collected in 1986. This species has since become the most abundant clam in the northern part of the bay, ultimately reaching densities of nearly 50,000 clams per square meter (Peterson,1996) and radically altering food-web dynamics, and augmenting contaminant transfer up the food web (Stewart et al. 2004). It is estimated that clams in the northern portion of San Francisco Bay have the capacity to filter the entire water column at least once and possibly more than twice in a single day (Thompson 2005).
- **Wakame,** an Asian seaweed (*Undaria pinnatifida),* arrived in Los Angeles Harbor in 2000, and has since spread as far north as Monterey Bay. One plant can release millions of spores capable of remaining dormant for many years before sprouting. Biologists fear it will either disrupt or hybridize with native giant kelp (*Macrocystis pyrifera*), endangering a keystone species of the California coast.
- **Japanese Eelgrass,** *Nanozostera japonica,* first established itself in the Pacific Northwest in the 1950s, probably arriving as packing material for oysters. It has since colonized hundreds of acres of bays in Washington and Oregon, growing in dense mats on formerly unvegetated mudflats. Studies suggest that the eelgrass displaces native burrowing shrimp and reduces habitat quality for feeding shorebirds. It was discovered in California in 2002 growing on the shores of Indian Island in Humboldt Bay.

Most of these species aren't the only invader in their newfound habitats. In combination, invasive species can have even larger scale impacts on the environment. In the Sacramento-San Joaquin River Delta, for example, a clam, a copepod and several plant species are all implicated in the sharp decline of pelagic fish such as endangered delta smelt. In this small silver fish's habitat, the invasive overbite clam has recently increased in abundance, possibly due to seasonal changes in outflows and salinity. This invader's higher abundance may be intensifying its impact on the pelagic food web upon which delta smelt depends. Meanwhile growing populations of another invader -- a spiney copepod -- may be linked to a further reduction in the amount of suitable food available for fish. Young of the smelt, not to mention the popular sport fish striped bass, may also be suffering from decreases in summertime habitat volumes and increases in predator friendly habitat caused by aquatic invasive weeds (Pers. Comm. Herbold 2006).

In sum, AIS can not only have direct ecological impacts on habitats, species and food webs, but can also confound efforts to restore and protect these resources. More details on specific AIS impacts and efforts to manage them can be found in the sidebars and case studies in Chapter's IV and V.

Economic Impacts

Most of the environmental impacts described above have associated economic costs, as managers invest time and money trying to minimize loss of species, habitats and natural resources to invaders. Other economic losses develop when AIS invasions hamper or jeopardize human activities. On a national level, invasions are costing American taxpayers billions of dollars every year in environmental degradation, lost agricultural productivity, expensive prevention and eradication efforts, and increased health problems. One nationwide estimate suggests that annual costs exceed $120 billion (Pimentel et al. 2000). This estimate falls short of being comprehensive on several fronts, examining only a small subset of harmful species, and not incorporating any of the costs of the environmental damage caused by these species, nor the benefits of introductions such as game fish (Lodge et al., 2006).

Those invasives that spread into aquatic environments can be particularly costly to manage. Pimentel (2001) estimated environmental losses to the U.S. totaling $1 billion a year from introduced fish, $2.13 billion from arthropods and $1.3 billion from mollusks. In an earlier study for the U.S. Congress, the Office of Technology Assessment (OTA) attempted to quantify economic impacts of 111 species of invasive fish and 88 species of mollusks. Of these only four fish species and 15 mollusk species resulted in major negative impacts—including the sea lamprey, zebra mussel, and Asian clam. OTA estimated that the cumulative loss to the U.S. for the period 1906-1991 for three harmful fish species was $467 million (1991 dollars) and $1.27 million for three aquatic invertebrates. Aquatic and riparian plant species can be equally high impact, especially salt cedar, purple loosestrife, melaleuca, and hydrilla, among others.

OTA reports that spending on aquatic plants control in the U.S. is $100 million per year (Stone & Lovell, 2005).

Another indicator of economic impacts can be government spending on invasives. In 1999 and 2000, the federal government spent $459 million and $556 million respectively on activities related to invasive species. Federal funding to address fish and aquatic invertebrates alone was $20.4 million in 1999. Annual federal funding to the U.S. Coast Guard, largely for programs to limit invasions via ship's ballast water, has been around $4.5 million (Stone & Lovell, 2005).

One of the most costly and well-studied North American invasions has been the introduction of the zebra mussel to the Great Lakes. The zebra mussel was first discovered in Lake St. Clair, a small water body connecting Lake Huron and Lake Erie, in 1988. By 2006, zebra mussels inhabited the waters of at least 20 states. This prolific mussel colonizes pipes, constricting flow and thereby reducing water intake for heat exchangers, condensers, fire fighting equipment, and air conditioning and cooling systems. Zebra mussel densities were as high as 700,000 per square meter at one power plant in Michigan, and pipe diameter was reduced by two-thirds at some water treatment facilities. One estimate puts the cost of scraping mussels from pipes in the Great Lakes region alone at $50-100 million per year (Maryland Sea Grant 2003). Zebra mussels also attach to boat hulls, docks, locks, breakwaters and navigational aids, significantly increasing maintenance costs and impeding transportation.

The zebra mussel has yet to be documented in California; however, it has been detected at border inspection stations on dozens of occasions. Based on the damage they have caused in the Great Lakes region, zebra mussels could seriously threaten California's entire irrigation network, as well as the canal system that transports drinking water for millions of residents in southern California. If either of these systems were to be damaged, the economic and social consequences are incalculable. A recent risk analysis calculated what the optimal allocation of resources to prevention might be, versus spending on control. The analysis suggests that it would be beneficial to spend up to $324,000 per year to obtain a modest reduction in the probability of a zebra mussel invasion into a single lake with a power plant (Leung et al. 2002).

In spite of the dire warnings from states already battling zebra mussels and quantitative analyses such as this, relatively few resources have been directed towards the pending threat to California posed by AIS like the zebra mussel. Indeed the first line of defense, border inspection stations where trailered boats arrive from infested states, are not adequately staffed.

Apart from potential costs of a zebra mussel invasion to water delivery and irrigation systems, AIS could also threaten or undermine other resources of great economic value to California. Recent statistics shed some light on the importance of California's water resources to residents and visitors alike.

- Commercial fish landed in California in 2005 had a value of over $106 million dollars (DFG Marine Fisheries Statistical Unit).
- Marine recreational fishing in California brought in an estimated $768 million dollars in expenditures in 2005 (National Marine Fisheries Service survey).
- Sportfishing licenses issued in 2005 were 1,978,143 (DFG License and Revenue Branch).
- Boats registered in California numbered 965,892 in 2005, and recreational boating currently contributes $17 billion annually to the California economy (DBW).
- California's travel industry and associated recreation contributes approximately $55.2 billion annually to the State's economy, according to the California Trade and Commerce Agency's Division of Tourism. Much of this recreational activity is centered on water, or water-based activities.

Recreational boating and fishing, in particular, have long been hampered by aquatic weeds and required some of the state's longest lived and most expensive management programs. Over the past three decades, for example, state agencies have spent more than $60 million to keep a handful aquatic weed species from impeding the navigation of rivers, lakes, bays and other waterways, not to mention causing other problems for fish, wildlife, agriculture and water quality.

- **Water hyacinth** (*Eichhornia crassipes),* was introduced into the United States in 1884 as an ornamental plant for water gardens, where its floating showy, lavender-blue flowers attracted many admirers. Able to double its size every ten days in hot weather, water hyacinth is the world's fastest growing plant. By 1904, the water hyacinth had made its way into a Yolo County, California slough. Recent surveys indicate that by early summer, the infestation can cover up to approximately 4,000 acres of the Sacramento-San Joaquin Delta (halved each year by treatment), and has spread to San Francisco Bay and the South Coast. At present, the aquatic herbicides 2,4-D and glyphosate remain the primary tools available to control water hyacinth (two weevils and a moth have been introduced as biological controls, but without much success). Programs to manage water hyacinth in the Sacramento-San Joaquin Delta, its tributaries, and the Suisun Marsh have been the responsibility of the state's Department of Boating and Waterways (DBW). Over the program's 22-year history, DBW's costs for water hyacinth control have mounted to approximately $25 million dollars, with annual spending currently around $2.5 million.
- **Hydrilla** (*Hydrilla verticillata)* was imported into the United States from Asia in the late 1950s for aquarium aficionados. The plant, which grows in dense mats, is most likely to spread when fragments are carried into new habitat by recreational watercraft. Hydrilla has been found in 17 of California's 58 counties. Working to eradicate hydrilla -- as well as managing other aquatic weeds and wetland plants such as purple

loosestrife, giant salvinia, and alligatorweed -- is the responsibility of the state's Department of Food and Agriculture (DFA). Since the 1970s, DFA has spent approximately $30 million dollars on aquatic weed control, with most of that money being focused on hydrilla eradication, which costs about $1.5 million per year. Such expenditures have enabled DFA to eradicate the plant from 19 sites in 12 counties, but much work remains to be done.

The expenditures of these two state agencies on aquatic weed control are just the tip of the iceberg. The two budgets described above do not take into account the cost of control efforts by other public agencies and private landowners, lost revenue due to decreased property values, or decreased use of water for swimming, boating, fishing, and other recreational activities

Needless to say, the harm done by invasives is a challenge to quantify. Environmental economists have been struggling to find a systematic method of quantifying human health values, use values, existence values and ecosystem values for decades. Invasive species add a level of complexity to the task that increases difficulties involved in such valuations. Rates of biological propagation, for example, don't always conform neatly with economic variables. Nor do assessments of the level of risk from invasives. Equally challenging can be attempting to quantify the benefits of preventing or controlling invasives (Stone & Lovell, 2005).

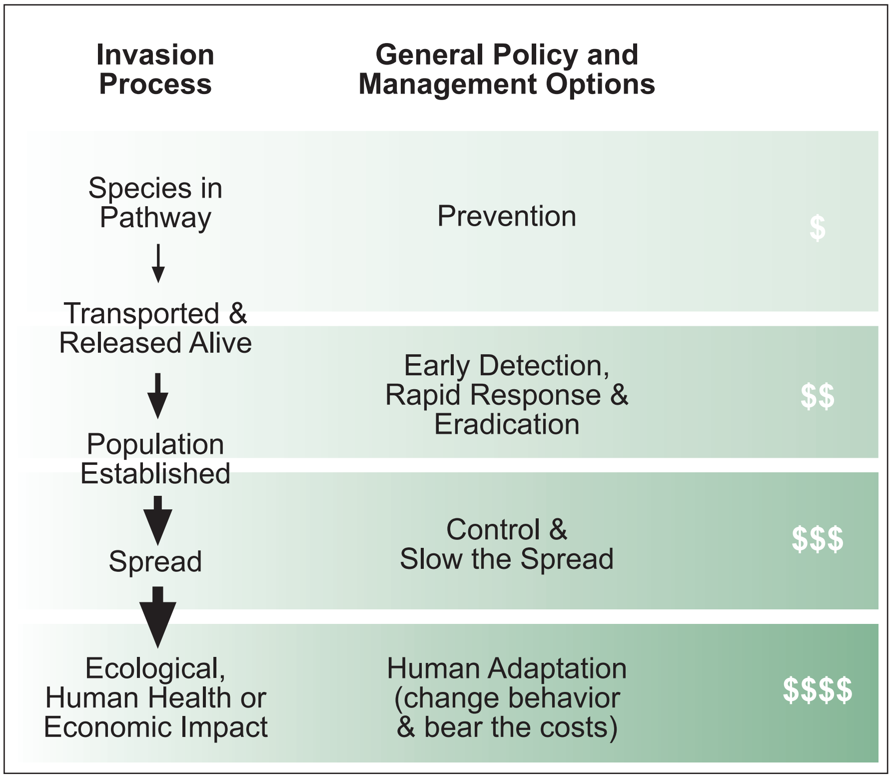
In general, however, costs mount as management activities shift from prevention to rapid response to eradication to control. Even rapid response isn't cheap. California's eradication efforts for the introduced marine alga, *Caulerpa taxifolia*, for example, have totaled over $7 million in federal, state, and local dollars since June of 2000 (see Chapter V, case studies).

Whatever the species or impacts, experts agree that the most costly response of all is inaction. Costs increase as invasions spread and become irreversible, and when the technology or chemicals don't exist to selectively eradicate species. Even when tools and political will for control exists, resources must be made available in perpetuity – not an easy task in the context of government funding cycles. While some control programs have been highly successful, many more have not even been attempted due to the perceived challenges and expense. On most management levels, the default response is adaptation—passively adjusting to the damages caused by new species—even when eradication or control would be a more cost-effective (Lodge et al., 2006).

California managers have attempted to address some of these challenges as they developed the state AIS action plan described in Chapter VI.

Figure 2: General Management Framework

Figure 2: General Management Framework



Source: Biological Invasions: Recommendations for U.S. Policy and Management, Position Paper of the Ecological Society of America, 2006

III. VECTORS OF AIS

Invasive species arrive in California via vectors -- the means or agents that transport species from one place to the next. Vectors, also referred to as pathways, include ships, fishing vessels, recreational boats, sea planes, diving gear, drilling platforms, dry docks, and industries that produce live fish, plants and other organisms for food, bait, aquarium pets, and other uses. Those undertaking shoreline restoration or construction projects or conducting water-based scientific or academic research can also be vectors. Invasive species cling to boat bottoms and recreational gear, attach to floating debris and docks, inhabit ship ballast water, and escape (or are released) from aquaculture packing materials, ornamental ponds, and aquariums into the state's waters.

In the past, efforts to control invasions have focused on managing individual problem species. More recently, however, the concept of focusing on vectors, rather than species, has begun to gain support as a more effective approach for aquatic species. Large vectors, such as Pacific Rim shipping, are not the only cause of large-scale invasions. Indeed seeming minor vectors can lead to major invasions. For example, the use of seaweed to pack bait worms from the U.S. Atlantic Coast brought the European shore crab *(Carcinus maenas*) to the Pacific Coast (Carlton PEW, 2001). Preventing introductions from smaller vectors can therefore provide significant ecological and economic benefits.

Once a highly invasive species arrives, preventing its rapid spread can be difficult if not impossible. For example, plants can produce thousands of seeds, which are carried by humans and animals to distant water bodies. Water flows and currents may also deliver these propagules to many new ecosystems. The West Nile Virus spread from New York across much of North America via hundreds of bird species. Chinese mitten crabs hatch into larvae that spend one to two months drifting as plankton; during this period, the tide can carry these invaders deep into vulnerable estuary systems. The difficulty and expense of turning back such a tide means that prevention is likely to be the first and the most cost-effective defense (Lodge et al., 2006).

Analyzing the risk of specific vectors represents a critical first step in preventing invasions. Only with examination of the larger picture can scarce management resources be applied in the most cost-effective manner. In this way, the relative risks each vector poses to the environment, human health, and the economy can be better evaluated. New genetic tools are now helping investigators detect the point sources of invasions. This information has helped provide a more quantitative analysis of pathway invasion risks (Lodge et al., 2006).

Figure 3: Common Marine Bioinvasion Vectors

Figure 3: Common Marine Bioinvasion Vectors

Invasion Vectors and Types of Organisms Transported

Ships

- Planktonic and nektonic organisms in ballast water
- Attached and free-living fouling organisms on hull, on rudder, on propeller and propeller shaft, in seawater systems, seachests, in ballast tanks, and in ballasted cargo holds
- Organisms associated with anchors, anchor chains, and anchor chain lockers
- Organisms associated with cargo, such as logs that have been floated for loading

Drilling Platforms

- Attached and free-living fouling organisms
- Planktonic and nektonic organisms in ballast water

Dry Docks

- Attached and free-living fouling organisms
- Planktonic and nektonic organisms in ballast water

Navigation Buoys and Marina Floats

- Attached and free-living fouling organisms

Amphibious Planes, Seaplanes

- Attached and free-living fouling organisms
- Organisms in pontoon water

Canals

- Movement of species through sea level, lock, or irrigation canals

Public Aquaria

- Accidental or intentional release of organisms on display
- Accidental or intentional release of organisms accidentally transported with target display species

Research

- Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in research (intentional or accidental escape)
- Organisms associated with research and sampling equipment, including SCUBA and other diving or swimming gear

Floating Marine Debris

- Transport of species on human-generated debris, such as floating nets and plastic detritus

Recreational Equipment

- Movement of small recreational craft, snorkeling and SCUBA gear, fins, wetsuits, jet skis, and similar materials

Fisheries, Including Marine Aquaculture (Mariculture)

- Transplantation or holding of shellfish, such as oysters, mussels, clams, crabs, lobsters, and other organisms; fish; or seaweed (algae) in the open sea for growth or freshening (rejuvenation); and other organisms associated with dunnage and containers
- Intentional release of shellfish, fish, and seaweed (algae) species, either as part of an official governmental introduction attempt, or as an illegal private release
- Stock enhancement, often ongoing, as well as accidentally transported associated organisms
- Movement of live seafood intended for sale but then released into the wild
- Processing of fresh or frozen seafood and subsequent discharge of waste materials to environment, which may include associated living or encysted organisms
- Movement of live bait subsequently released into the wild
- Discarding of packing materials—such as seaweed and associated organisms—used with live bait and seafood
- Movement, relocation, or drifting of fisheries gear, such as nets, floats, traps, trawls, and dredges
- Release of organisms as forage food for other species
- Organisms transported intentionally or accidentally in “live well” water, vessel scuppers, or other deck basins
- Release of transgenic stocks—genetically modified organisms (GMOs)
- Movement of algae and associated organisms as substrate for fish egg deposition

Aquarium Pet Industry

- Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in the aquarium industry (intentional or accidental escape)

Restoration

- Movement of marsh, dune, or seagrasses as well as associated organisms
- Reestablishment of locally extinct or decimated populations of native species, and accidentally transported associated organisms

Education

- Release of species from schools, colleges, and universities following classroom use

Source: Introduced Species in U.S. Coastal Waters, Environmental Impacts and Management Priorities, by James T. Carlton for the Pew Oceans Commission, Arlington, Virginia 2001 www.pewoceans.org

Many factors contribute to the invasion risk posed by a given vector. These include:

- number of nonindigenous species transported
- number of individuals of each species transported
- characteristics of the species (including their environmental tolerances)
- number and characteristics of their hitchhiking species (including parasites and other associated organisms)
- likelihood and frequency of a species and its hitchhikers reaching suitable habitat.
- feasibility and cost of eradication or control if a species becomes invasive (Lodge et al., 2006).

The live trade, including the pet, aquaculture, and horticulture industries, introduces far fewer exotic species than ships and other transportation vectors. However, prevention efforts aimed at this sector are well worth their cost. Providing education and oversight to these purveyors tends to cost less than comparable efforts aimed at transportation vectors and can preclude the far larger costs of stopping an invasion. Vectors of concern for freshwater ecosystems include stocking (especially of fishes), the pet industry, the bait industry, aquaculture, and the live food industry. The water garden and live food industries are growing rapidly and will likely become the source of more invasions in the future. These trades frequently put nonindigenous species of plants and animals in close proximity to natural waterways where they are more likely to find conditions suitable for establishment. In addition to intentionally transported species, these industries often deliver many hitchhikers such as small parasites, plants, animals, and pathogens. The burgeoning mail order/Internet trade has only increased the risk from these pathways (Lodge et al., 2006).

At present, the primary vectors for aquatic invasions remain largely unregulated. The little oversight legislation that does exist is not adequately enforced. But raising awareness of the invasion risks stemming from ballast water exchanges and hull fouling, as well as among aquarium, pet, nursery, aquaculture, and seafood industry groups, has great potential to change public behavior and develop cooperative guidelines for industry practices. In the end, these measures may significantly reduce the likelihood of AIS introductions (Lodge et al., 2006).

Although California's initial focus may have to be on high-risk vectors, the ultimate goal will be to assess, manage and prevent invasions from all vectors.

Vector 1. Commercial Shipping

Commercial shipping is often considered the principal means of unintentional AIS introductions to coastal and estuarine waters worldwide (Cohen and Carlton 1995, Thresher 2000). In coastal environments, commercial shipping is the most important vector for the introduction of NIS (Ruiz et al., 2000; Hewitt et al., 2004). In one study, commercial shipping accounted for one half to three-quarters of NIS introductions to North America (Fofonoff et al., 2003). The steady rise of global commerce, increased shipping activities, and shorter transport times suggest that the threat of introductions through this pathway is increasing.

California, as a coastal state engaged in significant Pacific Rim trade, cruise-line tourism, and commercial fishing, is vulnerable to the global rise in invasions. California hosts 11 major seaports: Hueneme, Humboldt Bay, Long Beach, Los Angeles, Oakland, Redwood City, Richmond, Sacramento, San Diego, San Francisco and Stockton. Three of these ports are among the top four busiest ports in the United States. Two of these ports are located a significant distance inland, and are slated for expansion, potentially importing more invasives deeper into the state. Together, all 11 seaports handled 23% of the United State's waterborne trade in 2003. In 2005, Long Beach and Oakland processed 56% of the nation's containerized cargo. Almost 95% of containerized Asian cargo destined for central and mountain states entered through West Coast ports --highlighting California as a first national line of defense against invasions (PMSA 2004).

Ballast Water

Shipping vessels commonly fill their ballast tanks with seawater from harbors after unloading cargo, and discharge it in another when loading more goods. The added mass of ballast water improves stability, trim, maneuverability, and propulsion in large, otherwise empty cargo vessels. Vessels may take on, discharge, or redistribute ballast water during cargo loading and unloading, in rough seas, or while moving through shallow waterways. Live marine organisms ranging from plankton to adult fish are regularly transported from source to destination ports when ballast water is discharged (Carlton and Geller 1993, Cohen and Carlton 1995). Estimates suggest that more than 7,000 organisms are moved around the world daily in ballast water alone (Carlton 1999).

Ballast water teeming with a wide array of non-native organisms arrives in the United States at the rate of about two million gallons per hour (Carlton et al., 1995). In 2005, 9.1 million metric tons were reported to have been discharged in state waters (SLC, 2006). California requires vessels arriving from outside the U.S. Exclusive Economic Zone (US EEZ) to manage their ballast water (see Chapter IV: Management Framework and Appendix C). Similar rules became effective for vessels engaged in coastal travel in March 2006.

Hull Fouling

Hull fouling may rival ballast water discharge as the leading historical cause of harmful AIS introductions (Thresher 2000, Hewitt 2002). Organisms such as mussels, seaweed, anemones, and sea squirts with sedentary life stages can attach themselves to the hulls of commercial vessels or become entangled in nets, anchors, and other gear. Barnacles, other seaweeds, and bryozoans may in turn attach to mussel shells and seaweed fronds, while more mobile species such as shrimps, worms, and sea snails may hide in crannies created by larger fouling species (Takata et al, 2006). These organisms can survive for extended periods of time once secured to a vessel. They are introduced to new waterways once dislodged, disentangled, or by spawning in new ports.

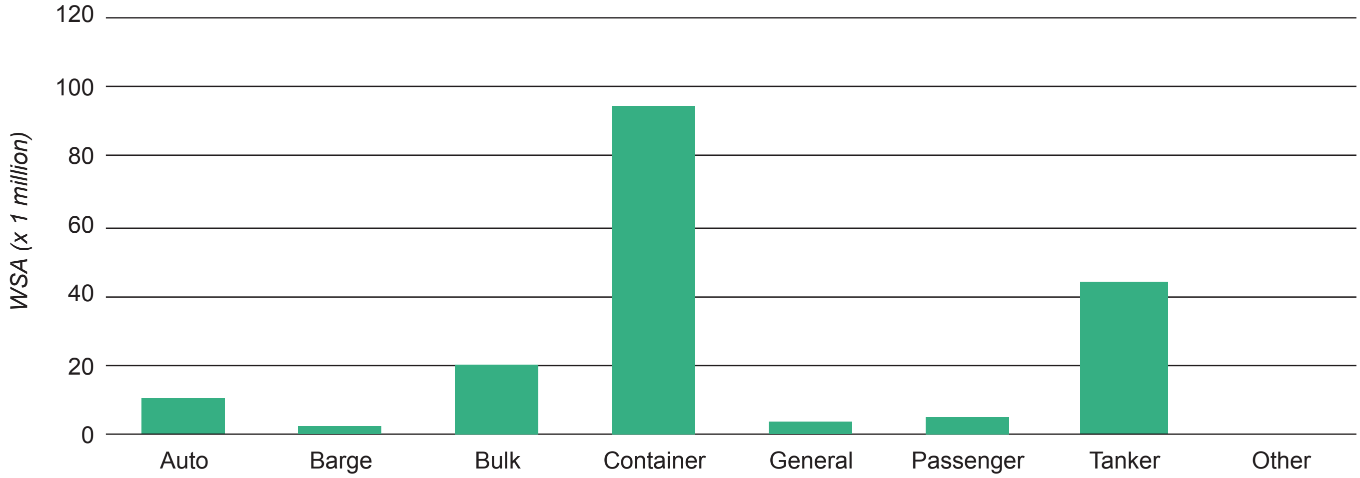
In an expansion of California's ballast water management program, recent legislation directed a team of technical advisors to formulate recommendations to prevent introductions through vessel fouling, among other non-ballast shipping vectors. The team's report documents the following factors concerning this vector:

Fouling has long been a nuisance to mariners. It creates drag, reduces fuel efficiency, can strain engines, and clog seawater intake pipes meant to cool machinery. As a result, hull cleaning is a routine part of ship maintenance. Antifouling paints and other systems have long been available to reduce the problem. These coatings generally function by releasing low doses of compounds toxic to marine creatures. Vessels that move slowly, spend long periods in port, take shorter trips, or are not repainted regularly pose particular problems. These vessels tend to accumulate more total fouling but also a more diverse assemblage of fouling species. Areas on a vessel that are shielded from much water flow may foul even in cases where main portions of the hull are clean (Takata et al, 2006).

Environmental factors such as salinity and water temperature influence organism survival and thus introduction rates. Exposure to a wide variety of salinity and temperature fluctuations may kill many intolerant organisms. This may explain why less fouling is observed on vessels traveling on long voyages that cross a wide range of latitudes (Takata et al, 2006).

Fouling organisms and potential invasive species transfer from the vessel to coastal waters and ports via spawning or egg release, detachment (simply dropping off into the water) or mechanical removal (via scraping, in-the-water cleaning, or blasting in dry dock depending on clean up procedures). Because fouling is affected by the type of commerce and environmental conditions in a specific region, local field research on the topic can be quite valuable. In a 2004 Port of Oakland study, researchers found local fouling patterns to be somewhat different from those in other regions.

Figure 4: Wetted Surface Area & Invasion Risk
Total wetted surface area (WSA) arriving to ports
July 2003 - June 2005 in California by vessel type



Total wetted surface area of commercial vessels arriving to California from July 2003-June 2005. The potential magnitude of the threat from hull fouling is significant, however, without reliable data on the extent of fouling found on commercial vessels, the ability to determine this risk is limited.

Data courtesy of Ian Davidson, Aquatic Bioinvasions Research and Policy Institute.

Source: Commercial Vessel Fouling in California: Analysis, Evaluation, and Recommendations to Reduce Nonindigenous Species Release from the Non-Ballast Water Vector, by L.Takata, M. Falkner & S. Gilmore, State Lands Commission, 2006.

Another study analyzed the total "wetted surface area" (WSA) of all vessel hulls arriving on the West Coast between July 2003-June 2005. The goal was to provide some indication of the rate and pattern with which individual organisms may arrive (propagule pressure), and how they may contribute to NIS establishment. The resulting two-year total of WSA entering California waters was 11/2 times the area of San Francisco County.

Figure 4: Wetted Surface Area & Invasion Risk

Regional differences in environmental conditions, vessel maintenance practices, types of shipping traffic, and vessel movement patterns all affect degree of fouling. In a few extreme cases, the risk of species introductions has been observed to be perilously high. For example, the decommissioned USS Missouri was found to have accumulated at least 116 fouling species during the five years it spent in Bremerton, Washington, before being relocated to Hawaii. A floating dry dock towed to Hawaii from San Diego in 1999 had high levels of fouling the included 34 NIS; a new species of algae became established in California as a result (Takata et al, 2006).

The majority of vessels in regular operation, however, are not at such extreme risk for fouling. Most hulls are cleaned and painted regularly for operational safety, to reduce maintenance costs, and to minimize drag-related fuel costs. Many spend as little time in port as possible and move cargo quickly for maximize profits. Consequently, the level of risk presented under more typical commercial vessel behaviors is unclear (Takata et al, 2006).

Vector 2: Commercial Fishing

While commercial fishing vessels traveling up and down the California coast and offshore do not usually carry ballast water, they can be an important AIS vector. They are more subject to the hull-fouling described above as they sit in harbors, docks, and berths during the offseason, and thus for longer periods than commercial ships (which travel so constantly through waters of widely varying temperature and salinity that their hulls remain relatively clean). Commercial fishing vessels can also carry AIS from one harbor to another via their fishing gear, lines, tackle, buoys, traps and nets. Researchers believe the Japanese seaweed, *Undaria pinnatifida,* may have been introduced to Monterey Bay by fishing vessels from other California ports. Though the state currently regulates ballast water, and may soon regulate hull-fouling, it has no authority over vessels under 300 gross register tons in size, such as commercial fishing vessels. More information is needed on the AIS risk from this vector.

Vector 3. Recreational Equipment and Activities

Boating & Sea Planes

The lakes, ponds, rivers, and coastal waters of California provide recreational opportunities for a large population of boaters. The movement of boats along the coast, as well as the overland transport boats and their trailers between water bodies, can introduce AIS that foul hulls, become entangled on motor propellers, and are small enough to be discharged in bilge pump water.

Invasive aquatic plants and other AIS can also be transported from one body of water to another through entanglement on aircraft pontoons. This presents an ecological risk to the receiving water, but can also create a navigational and public safety hazard should a lake become so clogged with plant material that it endangers aircraft takeoffs and landings.

Fishing

In addition to all the boating related risks described above, fishing boats pose additional risks when bait buckets are dumped. This practice may also release diseases or parasites hosted by the bait species. Gear used for fishing (nets, floats, anchors) and diving can also spread AIS. Even fly fishers can also be vectors. Wading boots, tackle and other gear in contact with waters infested with New Zealand mudsnails, for example, may be the primary vector associated with the spread of this AIS into California's Mokelumne and Calaveras Rivers. (Snails can survive for weeks out of water, and only mature to 5 mm in length, making them difficult to see on gear.)

Other Water Sports

Those engaged in California's diverse variety of other watersports – swimming, jetskiing, windsurfing, parasailing, scuba diving, waterfowl hunting – can all also be potential carriers of hitchhiking AIS as they move sports gear among coastal and inland recreational spots.

For all recreational water users, clear identification of AIS-infested waters through posted signs and by other means would reduce the risk of the transport of established invaders. This measure, along with vessel inspections and investigating the feasibility of installing washing stations for recreational watercraft, are actions in the management plan. Education of all these recreational users is also recommended in this management plan.

Vector 4. Trade in Live Organisms

Live Bait Industry

The shipment of live, non-native fishes or invertebrates into California for use as bait may serve as another pathway of AIS introduction. Frequently, packing materials are comprised of live plants that have the potential to become invasive. The seaweed *Ascophyllum nodosum*, native to the North Atlantic, is the primary packing material for marine baitworms (blood worms and pile worms) and American lobsters shipped to California. Bait worms are frequently packed in this seaweed when they are sold to anglers. This seaweed often harbors a substantial number and variety of exotic marine organisms. Of further concern is live bait that harbors parasites or pathogens that could endanger the health of human populations or native species. The State regulates the culture, import, harvest, and sale of fish species sold as bait. However, the sources of invertebrate imports to California for recreational fishing purposes are largely unknown and unregulated. Actions in the plan address the need to evaluate regulations designed to minimize the invasion threats from bait species.

Imported Seafood

The import, sale, and distribution of fresh, live seafood are historically important components of the California economy. The processing and sale of live fin and shellfish constitute AIS introduction risks through the intentional or unintentional release of live organisms as well as their associated parasites and pathogens. Specific seafood-related introduction pathways include packing materials, as discussed above under "live bait", and the following:

Shellfish waste disposal: Shells and other unwanted materials discarded following shellfish processing might harbor shellfish pathogens or live epiphytes as well as embryos or other developing stages of the shellfish species. Disposal of this material in or near a water body could result in unwanted introductions as well as other types of water quality impairment.

Bivalve wet storage: Holding shellfish in flow-through systems subjects surrounding surface waters to pathogens and other organisms that may be discharged during tank flushing. Transporting shellfish in nests of algae or other plants also poses the risk of introductions when these packing materials are discarded.

Creation of new fisheries: Several aquatic invaders, such as the Chinese mitten crab, *Eriocheir sinensis*, may have been released intentionally in hopes of founding a new and commercially valuable fishery (Whitlatch et al. 1995). Seafood suppliers and commercial and recreational fishers and anglers, who are unaware of the detrimental impacts resulting from these introductions, may be tempted to release these species into local aquatic systems to establish a self-sustaining population that can be harvested for consumption.

Aquaculture

California has the most diverse aquaculture industry in the United States. Like the seafood industry, aquaculture is an important sector of the California economy and has the potential for significant growth as more limits are imposed on wild fish harvests. While intensive culture of both finfish and shellfish reduces environmental impacts resulting from the harvest of wild stocks, concerns related to water quality impairment, growth, and distribution of pathogens, escape of non-native species, and genetic dilution indicate a need for careful planning in this industry. The following are examples of mechanisms for non-native species introductions through intensive aquaculture operations.

Shellfish seed import: Shellfish seed is commonly grown in hatcheries and imported to California for use in commercial operations such as oyster culture. While the State regulates the sources of seed for this industry, there is the potential for the import of shellfish pathogens and other organisms associated with shellfish, such as boring organisms, from outside of the state. An enhanced capacity to identify and manage shellfish diseases will be necessary to minimize the loss of shellfish due to these threats.

Abalone culture: Farmed commercial abalone is a small but productive industry that recently felt the sting of an introduced parasite. Their struggles with the South African sabellid worm, (*Terebrasabella heterouncinata*), offer a good example of what can happen when shellfish are transferred among hatcheries across state and national boundaries (see also Management Examples, Chapter IV). Although both abalone aquaculture and stock importations are regulated by the State, new guidelines for the movement of live organisms may be needed.

Use of shellfish waste: Several shellfish species cultured in California prefer clean, hard surfaces on which to settle and attach. Placement of shellfish waste as substrate in grow-out areas has raised concern over the source and proper disinfection of this waste material, and the potential of this practice to transport shellfish pathogens or other associated non-native species.

Finfish culture: Raising finfish in open systems such as raceways, flow-through tanks, and net pens exposes surrounding aquatic systems to pathogens commonly associated with cultured fish populations, and introduces the possibility of escape of the aquaculture species into adjacent waters. The State regulates this industry, and requires that species cultured in watersheds where they are not native be isolated from natural systems.

Genetic dilution: Strains of shellfish and finfish used in aquaculture such as salmon, are often imported or represent stocks that have been genetically altered or selected for particular traits such as large size or disease resistance. Cultured stocks are usually at a disadvantage in competition with wild populations in the natural environment. However, farmed Atlantic salmon have been documented to escape and survive in the wild to mate with Pacific salmon. Such interbreeding may dilute the wild genetic pool, resulting in offspring less adapted to life in natural systems.

California has addressed many of these concerns through existing legislation. However, several actions related to the prevention of introductions through the shellfish and aquaculture industries have been included in the plan.

Recreational Fisheries Enhancement

It is common practice in the United States for federal and state agencies to import game fish to enhance recreational fishing. Private citizens have also illegally transported and released their own favorite fish species into waterways in hopes that a viable population would survive. Non-native fish introductions in California peaked in the 1960s, when 13 new species were introduced (Moyle 2002). Illegal fish introductions, including species newly brought to the State and transfers of already-established species to new sites, are of increasing concern in California. There are 51 non-native freshwater fishes currently found in California; the majority were introduced deliberately (whether legally or illegally) in an attempt to enhance recreational fisheries (Moyle, 2002). Non-native fish are now the most abundant fish in many waterways in California, raising concerns about increased competition, predation, habitat interference, disease, and hybridization with native species.

Aquarium and Aquascaping (Water Garden)

Non-native marine and freshwater organisms can be introduced accidentally or purposefully after being imported for use in aquaria and water gardens (Carlton 2001). Aquatic plants available through these industries are often native to temperate regions, and are selected for their ability to thrive under adverse environmental conditions. Of additional concern is the mislabeling of imported organisms, particularly aquatic plants, which may then be confused with native or innocuous species and released by the consumer. Careful inspection of stock shipped and received is important; aquatic plants such as water lilies have reportedly been shipped from nurseries still entangled in fragments of invasive hydrilla plants.

Currently, the State monitors and regulates a limited number of species. However, the aquarium and water garden industries are largely unregulated in California and there is no screening process in place to evaluate the potential threat of new species being imported. Enforcement can be difficult, as California's nursery industry includes approximately 3,500 growers, 3,000 retail nurseries, and 3,500 "incidental dealers" such as supermarkets, drug-stores, and other chain-store type markets. Widespread use of the Internet for commercial sales of non-native aquatic plants and animals is particularly troubling. Federal agencies do have the authority to regulate sales of invasive plants and invertebrates through the aquarium and water garden trades. However, many species of concern, particularly freshwater aquatic plants, are readily available via the Internet and through mail order catalogues for water gardening. Some of the most popular AIS still commonly sold include water hyacinth, *Eichhornia crassipes*, parrot-feather, *Myriophyllum aquaticum*, Brazilian elodea, *Egeria densa*, water lettuce, *Pistia statiotes*, yellow floating heart, *Nymphoides peltata*, yellow flag iris, *Iris pseudacorus*, and frog's bit, *Hydrocharis morsus-ranae*.

More education and outreach, inspections, and enforcement are needed at both the state and federal level.

Research & Educational Activities

Marine and freshwater species can be ordered from research and education supply companies around the world through catalogs or Internet websites. While these organisms are generally supplied for research purposes, many companies also sell species for use in home aquaria. Few suppliers of live organisms, among them marine labs and research facilities, require documentation of use and handling practices prior to shipping. California's capacity to monitor and regulate the importation of species other than those on the prohibited species list is limited. Species obtained through mail order or the Internet pose a difficult problem. Control of introductions via this pathway is likely a federal responsibility, though states can play a role by ensuring that providers carefully monitor their shipments and provide recommendations for care and handling. Efforts can be made to provide information to Internet suppliers based in California about the risks of particular species. Educated consumers can provide an added level of security by carefully inspecting shipments after they are received and prior to release, to make sure they are not contaminated by additional AIS.

Once the organisms are delivered, improper handling techniques may result in the release of non-native species. Both lab and field practices routinely present the opportunity for AIS release through wastewater discharge, disposal of unwanted organisms, poorly contained studies, etc. At least one invasion (*Botrylloides diegensis*) in Massachusetts is believed to have occurred via this pathway (Whitlach et al. 1995).

Vector 5: Construction in Aquatic Environments

Many types of construction are conducted in aquatic environments, including the maintenance of canals and water delivery systems, the creation of shoreline parks and developments, the dredging of shipping channels and marinas, the control of riparian and levee-bank erosion, and the restoration of wetland, riparian and shallow water ecosystems. All of these activities, and the equipment used to accomplish them, can transfer or introduce AIS.

Construction Equipment: The use of contaminated construction equipment, and the transport of sands and sediments during marine construction (building and installation of docks, platforms, bulkheads, breakwaters, artificial reefs, etc.) can lead to the introduction of unwanted AIS. Similarly, the use of heavy machinery, such as harvesters and dredges, to remove AIS and/or sediments from infested water bodies, can spread AIS from one site to another if the equipment is not properly cleaned between projects.

Canals, Channels, and Aqueducts: The building of canals, channels, and aqueducts creates artificial connections between waterways, allowing the free movement of species across physical barriers. Increasingly in California, fish are being introduced into new areas by aqueducts that bridge drainages (see below).

Ecosystem Restoration and Erosion Control : Historical examples abound of non-native plants being introduced to California for habitat restoration and/or erosion control with disastrous results; these include *Spartina alterniflora, Tamarix ramosissima, Arundo donax*, to name a few. Awareness of this problem needs to be increased and alternative plant choices must be made available and encouraged or required. Equipment used during habitat restoration and subsequent monitoring should be cleaned to avoid transferring AIS from one site to another.

Vector 6. Water Delivery & Diversion System

The state's extensive water delivery, export, transfer and development system, which moves water not only from one watershed to another, but also from one end of the state to another, and even across state lines, can be an important vector of AIS. Water deliveries can spread freshwater-adapted AIS within and out of state, and carry species from infested areas to more pristine locales. For example, the yellowfin goby, *Acanthogobius flavimanus*, was first found in the San Francisco Estuary, then in the Delta-Mendota Canal, a feature of the Central Valley Project. The goby was later found further south, in the California Aqueduct, which is part of the State Water Project and transports water from northern and central California to the Los Angeles area. More recently, the goby has been found in the San Luis Reservoir in the western San Joaquin Valley. The California Aqueduct has transported a number of species, both native and invasive, and scientists have already identified species they predict will travel to new locales on this waterway, such as the shimofuri goby, first found in the Suisun Marsh northeast of San Francisco, and more recently in Pyramid Reservoir, 39 miles from downtown Los Angeles.

A significant amount of water, and whatever AIS are within it, is moved around California each year for human use. California's water delivery system, and the rivers that feed it, such as the Sacramento, San Joaquin, and the American, supply not only drinking water but also irrigation water for nearly ten million acres of farmland. The state's two largest water distribution systems, the State Water Project and the federal Central Valley Project, can move up to four and seven million-acre feet of water each year respectively, but at least 7,000 other users also have permits to divert water. During the period 1998 and 2001, approximately 30.2-36.6 million acre feet of water were diverted from their original courses annually in the state of California. Of these transfers, between 3.9 and 4 million acre feet of water transfers came from the Colorado River. (Natural flow from Oregon's Klamath River to California also supplied a significant amount of water, ranging from 0.98 to 2.1 million acre feet each year.)

The likelihood of spreading aquatic invaders via water diversion is not proportional to the amount of water that is being transferred. Often, water is moved to a water treatment plant where it will be processed into safe drinking water, or to agricultural fields inhospitable to aquatic species. Water turbines may be fatal to invasive species. When an invasive species arrives in a new location, the species is not always able to establish itself. Mitten crabs transported to an agricultural canal near Bakersfield, California by the Central Valley Project, for instance, cannot establish a viable population because they need access to an estuary to complete their lifecycle.

Water managers are working to better track AIS in their equipment and systems. State and federal project managers, for example, have moved forward on monitoring AIS by counting mitten crabs which clog the fish screens at fish collection facilities in Tracy, California, where water is diverted from the Delta. Native and non- native fish are counted, collected, and salvaged. And new fish species have been noted at these facilities. Less extensive sampling, mostly to determine fish loss, is conducted at other regional water diversion facilities.

Intensive manipulation of natural water paths and river flows, and of the aquatic ecosystem in general, makes California particularly vulnerable to AIS. Not only may AIS be more easily transferred via all these diversions, but they may also find it easier to colonize areas where native species are already stressed by the loss of habitat caused by dams, water diversion, altered hydrology, and development.

Conclusion

The above is only a discussion of the primary vectors of aquatic species invasions. In the past 200 years the number of vectors available to transport of marine species has steadily increased. In the year 1800, ships and ballast rocks were the major mechanisms. By 2000, there were at least 16 known human vectors (Carlton Pew 2001). The increasing diversity of vectors makes the prevention of introductions an even greater challenge.

IV. MANAGEMENT FRAMEWORK

California has been working to prevent, manage and control aquatic species invasions for decades. Seven state agencies are actively involved in large-scale ongoing AIS management programs, and numerous other California agencies, as well as local and federal interests, also play a role. Some state management programs focus on a specific vector (commercial shipping, aquaculture, etc.), some on specific nuisance species, or a group of species (such as agricultural pests), and some on minimizing AIS impacts on protected uses of the state's waters (boating, fishing, wildlife habitat, etc.).

This chapter explores the following five subject areas:

- The generally accepted management framework and control options for aquatic invasive species;
- A summary of current California state AIS authorities and programs.
- Summaries of state and federal codes and laws related to AIS management.
- A coordinating framework for future state activities.
- A list of gaps and challenges in state AIS management.

A comprehensive listing of AIS-related state and federal laws, authorities and agencies can be found in Appendices B, C and D. A list of regulated AIS species can be found in Appendix G.

Framework

On a general level, invasive species management involves five basic strategies, often in combination:

1) Prevention
2) Monitoring and Early Detection
3) Rapid Response & Eradication
4) Long-Term Control and Management
5) Education and Outreach

This basic framework is well established on a national level, is also reflected in California's existing *Pest Prevention Program and Weed Plan*, and forms the foundation of management actions described in this new AIS plan.

In choosing management approaches within this framework, the nature of the invader itself comes into play. Some invaders (such as the Zebra mussel) may be known troublemakers in other states or nations but have not yet arrived on California's shores, suggesting a management response focused on monitoring, education and early detection. Other invaders (such as the water hyacinth choking boating channels and lakes) may be so well-established that ongoing chemical and mechanical removal in infested areas is the only possible response. Still others (such as the Asian clam colonizing the floor of Suisun Bay) may present no management option whatsoever – there is no environmentally-acceptable way to treat or remove widespread benthic invertebrates in open waters. Whatever the species, the possible human management responses generally narrow as any invasion progresses (Lodge et al., 2006).

Prevention

Preventing AIS introductions is the single most cost-effective and environmentally beneficial management approach, and the first line of defense. This approach focuses on preventing the release of AIS into state waters via ships ballast water, fouled hulls, marine equipment movements, aquatic research activities, and by the producers and buyers of bait, aquariums, seafood and other live organisms. California's pest prevention program for noxious weeds refers to this type of prevention as exclusion (keeping the species out of the state). Prevention programs focus on minimizing the introduction of all species into the environment via specific vectors. This is because it is very difficult to predict which species will invade and cause significant impacts, and because it is difficult to identify many potential aquatic invasive species (especially very small invertebrates, parasites, and unicellular organisms). Inspection programs are part of prevention, but generally target specific species rather than vectors. Prevention programs may include everything from inspections of stores, industries or facilities that may be harboring or selling an AIS of concern to regulating industries (i.e. ballast water discharge on commercial vessels) to the state to education and outreach on state and national levels.

One of California's oldest prevention programs focuses on aquatic and terrestrial weeds. The state maintains a noxious weed list and manages an exclusion program both at borders and at entrypoints such as pet/aquaria stores, aquatic plant dealers, and nurseries (see Chapter IV, Current Management Activities). Another of the state's comprehensive prevention programs addresses AIS introductions from ship's ballast water (see Chapter IV, Current Management Activities and Appendix C). To prevent release of ballast containing live organisms from one port or country into another, vessels now have four options: retention of ballast water, mid-ocean exchange, discharge to a shore-base treatment facility, or the use of an alternative treatment technology. As shore-based treatment is yet to come on line, ballast water exchange, the process of exchanging coastal water for mid-ocean water, is presently the most broadly applicable method for managing the risk of AIS introductions.

During the ballast exchange process, biologically rich water loaded at the last port of call is flushed out of ballast tanks with the water from the open ocean, typically beyond 200 nautical miles (nm) from land. Organisms are generally less numerous in the open ocean, and it is expected that they will be poorly adapted to survive once discharged in the very different environmental conditions of a nearshore port. Scientific research indicates that offshore ballast exchange typically eliminates 70% - 95% of the organisms originally taken into a tank while at or near port (Zhang and Dickman 1999, Parsons 1998, Cohen 1998). Other studies suggest that exchange efficiency is inconsistent, and ranges from 50-90% (U.S. Coast Guard 2001). Most experts view ballast water exchange as a short-term solution, with the final resolution being a combination of treatment technologies and management options. In the meantime, agencies are considering the development of performance standards for ballast water exchange (SLC 2005).

California requires each vessel to fill out a ballast water report form, which allows the state to quantify how much ballast water is coming into California, where it is coming from, and how it is managed. Quantifying this vector is a critical step in being able to create an effective management program.

Ballast water management is just one aspect of prevention. It is also one of California and the nation's few "regulated" programs, and the only program that has had a quantitative state-wide assessment. Preventive measures on other vectors – and education of all those who might accidentally introduce AIS to state waters -- are also important but to date have not been as well funded, coordinated, and assessed as the ballast water vector. As prevention is the least expensive and most-effective management response, every vector deserves state level consideration and coordination.

Monitoring, Early Detection & Rapid Response

Some species will evade prevention programs. A few of these will spread, after a certain lag time, and become pests. The lag time between establishment and spread (weeks to 1-2 years) offers an opportunity for detection and eradication. Taking action while populations are small and localized is extremely important, but the effort required to detect a species can be inversely proportional to its population size. Sound management must balance the high costs of surveys aimed at detecting small populations over a wide area against the high costs of eradication if a survey fails to catch an invasion early on. New surveillance technologies and web-based reporting and information networks may help increase the success of rapid response (Lodge et al, 2006); so may enlisting the help of citizen monitors, watershed groups, professional diving associations, and others often in and out on the water.

Rapid response often involves eradication by chemical, mechanical or other means, which works best when the invader appears in an isolated lake, creek or other water body where spread can be contained and the environmental impacts of any chemicals used to kill the invader minimized. Eradication may be possible in isolated areas of one part of the state while larger scale control programs may necessary in others where infestations have spread. For this reason, it is sometimes hard to categorize existing response programs as either "eradication" or "control." Such measures often go hand-in-hand on a statewide scale.

In order to effectively respond to the early detection of an AIS occurrence, several states (including California, see Appendix A) have developed formal interagency rapid response plans. The goal of such plans is to make the roles and responsibilities of various agencies clear, and to provide a structure for chain of command decision-making, the protection of public safety, streamlined permit approvals, data collection, implementation and follow up evaluation. In other words, a rapid response plan lays out how federal, state, and local officials should respond if an AIS of particular concern (such as the zebra mussel, see below, or the marine algae *Caulerpa taxifolia*, see Chapter V) is detected.

To be more effective, rapid response programs should include specific examples that can be used as templates for certain types of invasions, as each invasion may involve different agencies, landowners, habitat types, permitting requirements and management responses. Rapid response is often critically delayed by permitting processes developed for maximum public input and thorough review, rather than for emergency response timelines. Both federal and California agencies have embraced the need for special levels of coordination and cooperation to facilitate rapid response.

MANAGEMENT EXAMPLES: ERADICATION SABELLID WORMS & ZEBRA MUSSELS

The South African sabellid worm, Terebrasabella heterouncinata*, was imported to the United States in the 1980s in an abalone shipment from South Africa. By 1993, abalone growers in Cayucos, California began to notice defects such as misshapen, stunted, and brittle shells in their stock. The worm causes shell lesions that compromise the abalone's overall health and marketability. The worm quickly spread to other abalone farms via seed stock and to rocky intertidal habitat nearby. The resulting infestation spread to native black turban snails. University of California, Santa Barbara researchers removed more than a million infected snails from the area, eradicating the worm from the wild in California. State agencies now closely regulate transfers of abalone between aquaculture facilities and have established a two-year certification program to ensure buyers that shellfish stocks are sabellid-free.*

Though not in California, a 2006 success story in early detection marks the first successful extermination of zebra mussels in open waters. In 2002, the mollusks were discovered growing in a twelve-acre abandoned rock quarry in Virginia. With neither a native mollusk population nor any surface water outlets, the site was deemed ideal for mussel eradication. In 2006, the quarry was treated for three weeks with twice the concentration of potassium chloride found to be lethal to zebra mussels. Eradication was confirmed by a variety of measurements. Concentrations of potassium chloride in quarry water remained well below levels harmful to other wildlife; turtles, fish, aquatic insects, snails and other wildlife in the quarry do not appear to have been affected by the treatment. Unfortunately, the large volume of potassium chloride required makes the technique impractical to apply in bodies of water as large as the Great Lakes.

Slow the Spread & On-Going Control

When eradication is not feasible, containment or at least a "slow the spread" strategy may be the best choice, particularly when management costs are likely to be exceeded by the environmental or economic costs of allowing an invader to proceed unmanaged. Control programs often occur over many years, involve multiple sites and waterways, and present an often-losing battle to manage the movements of small seeds, spores, larvae and specks of algae across huge landscapes and waterscapes.

<u>MANAGEMENT EXAMPLES: MINIMIZING LOOSESTRIFE AND MITTEN CRAB IMPACTS</u>

Purple Loosestrife, Lythrum salicaria*, is a wetland invader imported from Europe in the early 1800s for its medicinal value and beautiful purple flowers. A large plant can produce more than two million viable seeds in one season. Purple loosestrife is still sold as an ornamental in nurseries in some states, though at least 24 states, including California, have listed it as a noxious weed and prohibit its sale. In California, it is rapidly expanding its range. There is an ongoing effort to survey state populations and develop management plans for each. Eradication will be the goal where feasible. However, direct suppression with herbicides and other methods may be the only alternative in other places. The plant is extremely difficult to eradicate, although a suite of insects has provided effective biological control in some areas.*

Although the Chinese mitten crab, Eriocheir sinensis*, had previously been found elsewhere in the United States, San Francisco Bay was the first introduction that resulted in the establishment of an extensive population. Burrows excavated by the crabs erode banks and could damage levees. The crab's sharp claws can cut through commercial fishing nets and reduce or damage catch. The mitten crab also hosts a human parasite known as the lung fluke, which can cause tuberculosis-like symptoms. In fall of 1998, as many as 1 million mitten crabs were collected at the federal and state fish salvage facilities in the south delta, which are associated with the California Aqueduct and State Water Project. The crabs clogged the screens, holding tanks, and transport trucks used to salvage fish from the pumping stations. The state built "Crabzilla" – an18-foot high traveling fish screen at its Tracy fish collection facility to scoop up the crabs so they can be hauled off and ground up for fertilizer. Mitten crab numbers declined after 1998, and in 2005 were at very low numbers throughout the watershed.*

Education and Outreach

Regardless of what the management response is, and the scale or type of invasion, it is critical to establish ongoing communication with all those impacted, involved, or potentially perpetrating the problem. Education and outreach – whether it's public service announcements and media campaigns or species identity cards, volunteer training or school programs – all play an important role. Education and outreach go hand-in-hand with all phases of AIS management, including prevention, monitoring and early detection, rapid response and eradication, and long-term control.

<u>MANAGEMENT EXAMPLES: NATIONAL AWARENESS CAMPAIGNS</u>

Numerous education campaigns seek to improve public awareness issues of AIS issues on a national level. Habitattitude, for example, was started by the U.S. Fish & Wildlife Service and the national Aquatic Nuisance Species Task Force ANS Task Force and the pet industry. This campaign focuses on promoting consumer awareness and responsible behaviors for aquarium and water garden hobbyists and in the industries that serve them. Two other national campaigns, meanwhile, are already working to educate water users about how to prevent the spread of AIS: Protect Your Waters & Stop Aquatic Hitchhikers is an educational campaign aimed at all recreational users (protectyourwaters.com); and the 100th Meridian Initiative is a campaign aimed at stopping the spread of the zebra mussel and other AIS into the West. For more information on these campaigns see Appendix D.

Figure 5: Species Management Types

Figure 5: Species Management Types

SPECIES TYPE	REPRESENTATIVE SPECIES	MANAGEMENT RESPONSE
Type 1 Not yet in California or eradicated	*Caulerpa* Northern pacific seastar Southern african sabellid worm snakehead Zebra mussel	Monitoring Early detection and rapid response
Type 2 Limited in extent	*Hydrilla* *Salvinia* Smooth cordgrass	Early detection Rapid response And eradication
Type 3 Established but manageable	African clawed frog *Egeria* Chinese mitten crab Eurasian watermilfoil European green crab Purple loosestrife Saltcedar Water hyacinth	Impact mitigation Control of spread to other water bodies Research on control technologies
Type 4 Widespread but no large-scale control options	Asian clam Inland silverside New Zealand mudsnail Bullfrog Water lettuce Yellow flag iris	Monitoring to prevent spread to new water bodies; no large-scale control options
Type 5 Unknown invasion potential	Channeled apple snail Asian swamp eel Green sunfish Nuclear worm Salt meadow cordgrass	Further evaluation

Included species are meant solely to help clarify the parameters of each category. Though valid at the time of publication, the status of the species mentioned is likely to change and evolve over time. For more examples see Chapter V.

Current State of California Management Activities

Within the management framework described above, the state of California is currently involved in diverse AIS prevention and control programs. Historically, however, these invasive species management activities have been divided into two types – weed control, which has been largely focused on terrestrial, agricultural and forestry impacts in the past, and control of aquatic invasive species through ballast water management. While weed management has remained centered in one or two agencies, the management of aquatic invasive species has been spread across a variety agencies depending on the vector, the type of species, and the impact of the invasion. Likewise, management approaches to weeds are much more well-established than those for managing aquatic invasives. Most of the former programs are targeted at managing pests that damage agriculture and cause economic harm. There are comprehensive state and federal lists documenting agriculture pests, so management programs are targeted at specific species (all 130 plus weeds on California's noxious weed list have a rating tied to a management strategy). Species can be added to the lists and their ratings can change.

Managing aquatic invasive species is a more recently developed discipline. In addition, aquatic invasive species have not been studied as much as agricultural pests and terrestrial invaders. Thus the biology and impacts of AIS species that are expected to become invaders are not as well understood. Because of this difference, management of aquatic invasive species must take a broad approach, and focus on preventing vectors from bringing in new species, and developing early detection networks that can identify newly established organisms (even if they haven't been described as an invader in the past).

The principal, current state activities for managing AIS are described below. This is intended as an overview, rather than a comprehensive description (see Appendices A & C).

Biological Surveys, Environmental Planning & Enforcement:

The California Department of Fish and Game (DFG) is one of the lead agencies for managing invasive species, and it's Habitat Conservation Branch houses the state invasive species coordinator. DFG conducts a number of programs related to aquatic invasive species, including serving as the lead agency in developing this statewide AIS management plan, as well as a rapid response plan for invasions (see Appendix A). DFG is responsible for enforcement of regulations concerning the aquaculture industry; recreational fishing; commercial fishing; the importation and transport of live wild animals, aquatic plants and fish into the state; and the placement of any such animals in state waters. Recent programs have focused on the aquarium plant *Caulerpa taxifolia* (see Chapter V), the voracious fish northern pike (see below), and the New Zealand mudsnail, among others.

DFG is also responsible for conducting biological surveys to assess the amount and types of AIS present in state waters. Starting in 1999 with ballast management legislation, DFG's Office of Spill Prevention and Response (OSPR) conducted biological surveys to determine the degree of success of ballast water management activities. The first survey of major ports, harbors and bays of California helped determine a baseline of non-indigenous aquatic species introduced from the ballast of ocean-going vessels. The survey revealed that all areas of the California coast have experienced some level of invasion by species not native to California. Since then, DFG/OSPR has revisited baseline monitoring sites and expanded monitoring to include intertidal and subtidal habitats at 22 outer coast sites. DFG/OSPR also manages the California Aquatic Non-native Organism Database (CANOD), and is working to establish consistency among the various major databases being used to analyze similar types of AIS-related information. Lastly, DFG has been an active manager or partner in numerous AIS eradication and control programs – especially those AIS that threaten or undermine the health of endangered species or the conservation and restoration of the aquatic ecosystem.

MANAGEMENT EXAMPLE: CONTROLLING NORTHERN PIKE

Though California's northern pike infestation is currently limited to just one lake, the fish is proving tough to eradicate and is now near the top of the state's priority list. Esox lucius *-- a native of northern waters from Asia to Europe, and from Alaska to the Great Lakes Region -- is a voracious predator that can grow up to 40 pounds in North America. It uses sharp teeth to eat creatures ranging from smaller fish such as juvenile salmonids to frogs, crayfish, and even ducks. After introduction, it has the potential to dominate water bodies such as lakes, by both preying on and out-competing trout and other game fish. The pike poses a major threat to California's aquatic ecosystems, in particular the freshwater species of the Sacramento-San Joaquin Delta. The northern pike was introduced to California on at least two occasions, possibly by anglers hoping to establish a local population of this popular game fish. It was first found in Frenchman Lake, Plumas County, in 1988.*

In 1991, Frenchman Lake and its tributaries were treated with the rotenone; subsequent testing indicated no pike survived. In 1994, the pike was discovered again in nearby Lake Davis, another Sierra Nevada reservoir. In 1995, DFG proposed to treat Lake Davis with rotenone in order to protect the area's thriving trout fishery, as well as downstream aquatic resources, by eliminating the chance of pike escaping to other waters. Residents strenuously opposed the plan, citing contamination of their drinking water supply. By 1997, the lake's trout population had been virtually eliminated by pike predation. Local businesses, many of which depend on visiting fishermen, began to suffer. Despite the controversy surrounding the proposed project, a treatment occurred in October 1997. Over 55,000 dead pike were removed from the lake, and the treatment declared successful. In 1999, just 17 months after treatment, more pike were found in Lake Davis. It is unknown whether fish survived the treatment or pike were illegally introduced after the treatment. After the fish were rediscovered in Lake Davis, DFG commenced trapping, electrofishing, netting, and increased law enforcement and education on the dangers of pike introduction. Yet fish numbers in the lake have continued to rise. In 2005, DFG proposed rotenone treatment in combination with a significant lake drawdown; the drawdown would reduce the amount of chemical needed to kill the pike. DFG, in cooperation with the U.S. Forest Service, Plumas National Forest, are currently engaged in a joint state and federal environmental review process for the proposed project and a number of alternatives. Both agencies are working closely with the local community to avoid the controversial nature of the chemical treatment that occurred in 1997.

Aquatic Weed Control & Plant Pests

The California Department of Food and Agriculture (DFA) has long regulated and managed aquatic and terrestrial weeds, with a particular emphasis on those that are agricultural pests or cause economic harm. DFA activities and regulatory authority include quarantine, exterior pest exclusion (border stations, inspections), interior pest exclusion (pet/aquaria stores, aquatic plant dealers, and nurseries), and detection and control/eradication programs. DFA maintains a rated list of noxious weed species, which, depending on the rating, require various levels of eradication, containment or holding actions. For all plants, the DFA Plant Pest Diagnostic Center identifies plant species and assigns plant pest ratings. In 2005, DFA and the California Invasive Weed Awareness Coalition completed the state's first comprehensive noxious and invasive weed action plan, whose recommendations as they relate to aquatic weeds have been taken into account in this AIS plan (there is currently no comprehensive framework in state government for regulation invasive plants that are not legally defined as noxious). One of DFA's largest aquatic weed management programs is a statewide effort to eradicate the escaped aquarium plant hydrilla (see also Chapter II).

The California Department of Boating and Waterways (DBW) manages the state's largest and oldest aquatic weed control program, working with other public agencies to control the widespread water hyacinth (*Eichhornia crassipes*) -- and more recently Brazilian elodea (*Egeria densa*) -- in the Sacramento-San Joaquin Delta, its tributaries, and the Suisun Marsh. In addition to managing these weed control programs and attempting to keep waterways free of the navigational problems they pose, DBW also has the authority to manage the recreational boating vector of AIS in California (although there is not currently funding and staff for a comprehensive program). DBW leads the California Clean Boating Network – a collaboration of government, business, boating, and academic organizations working to increase and improve clean boating education efforts, including invasive species education, across the state

The California State Coastal Conservancy (CC) has been involved for over twenty years in the control and eradication of aquatic invasives, particularly plants. Most recently its management focus has been on developing, funding and operating the Invasive *Spartina* Project in San Francisco Bay (see Chapter V and Appendix B). The project's aim is to eradicate various invasives species of *Spartina*, and its hybrids, that threaten to destroy mudflats and drainage channels. The Conservancy is also heavily involved in efforts to control *Arundo* in many coastal watersheds, and has been a partner in developing this state AIS management plan.

Commercial Shipping Management (Ballast Water and Vessel Fouling)

The California State Lands Commission (SLC) oversees management of AIS introductions through commercial shipping as directed by the 2003 Marine Invasive Species Act. This program works to implement regulations governing ballast water management for vessels operating on the West Coast of North America. Commission inspectors board approximately 25% of all vessels that arrive to California to verify compliance with regulations, and to disseminate outreach materials to vessels and crews new to California. Monitoring results suggest that vessel compliance with the requirement to report ballast management and discharge practices is very high, and has risen dramatically since the inception of the program (the vast majority of non-compliant ballast water discharges originated from Mexican and Central American waters). The high compliance rates are attributable to the multi-pronged outreach and communication activities undertaken by the SLC. Inspectors distribute information verbally and in print to crews on regulations. Agents are notified monthly of their vessels' reporting compliance or non-compliance. Multi-agency, multi-interest advisory groups are continually convened and consulted regarding evolving policy considerations. In addition to its regulatory activities, the Commission facilitates scientific research and technology development to enhance management efforts of the program, and to inform policymakers. The SLC has also been coordinating interagency efforts to manage invasive aquatic plants, such as Eurasian watermilfoil (*Myriophyllum spicatum*), in Lake Tahoe (see Chapter V).

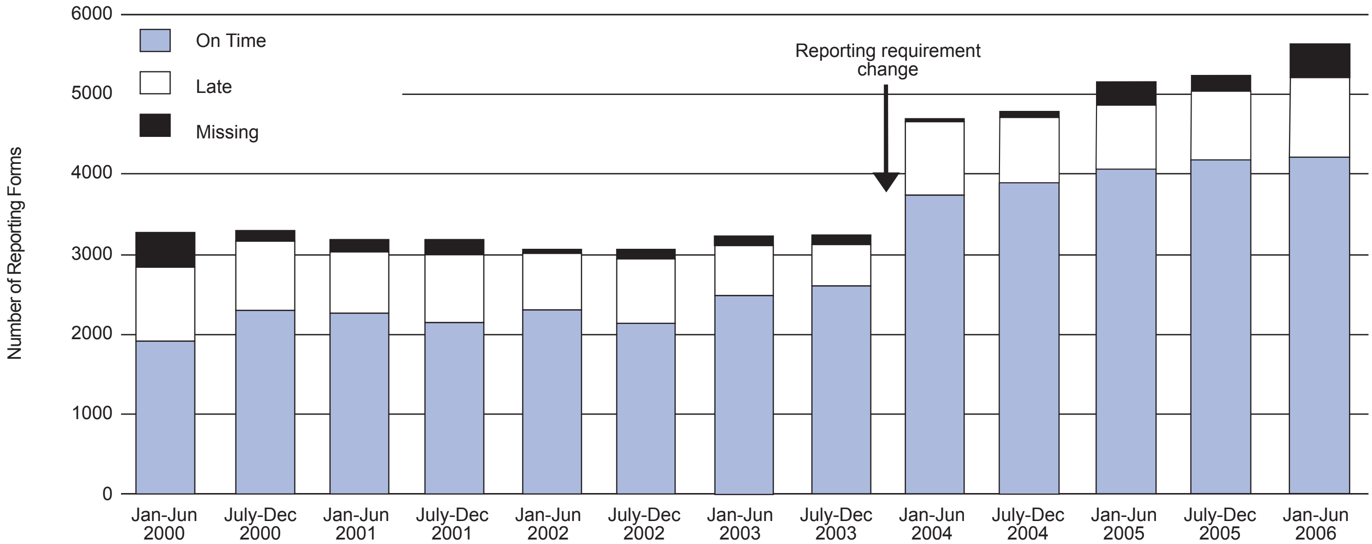
Figure 6: Ballast Water Compliance & Management

Monitoring & Managing AIS Impacts on Water Quality & Supply

The California Department of Water Resources (DWR) addresses invasive species issues that impact water supply and delivery, and flood control. Recent management activities have focused largely on monitoring AIS within the water column and food web, developing key early detection programs, and undertaking structural improvements such as a barrier at Lake Davis (to prevent northern pike escape) and a screen at the State Water Project (to collect Chinese mitten crabs). In terms of monitoring, DWR conducts monthly monitoring of benthic (bottom-dwelling) invertebrates, zooplankton and phytoplankton throughout the upper San Francisco Estuary, and also documents the distribution of the invasive algal species Microcystis spp. (both toxic and non-toxic strains) in this estuarine region. DWR is also investigating the impacts of the Chinese mitten crab on the benthic invertebrate community in the Sacramento-San Joaquin Delta. On the early detection front, DWR was most recently responsible for implementing the California Zebra Mussel Watch Program (which included risk assessment, early detection, public outreach, and the development of a rapid response plan for the Central Valley watershed and a centralized reporting system for mussel sightings).

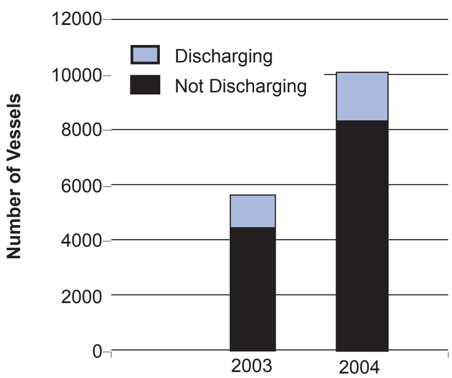
Figure 6: Vessel Reporting Rates 2000-2006

Illustrates rates of vessel compliance with requirement to report ballast management practices to the California State Lands Commission. Prior to 2004, vessels were only required to send reports for the first call to a California port. Beginning in 2004, new legislation required that vessels report at every California port or place visited.



Reported Discharge vs. Retention in 2003 and 2004

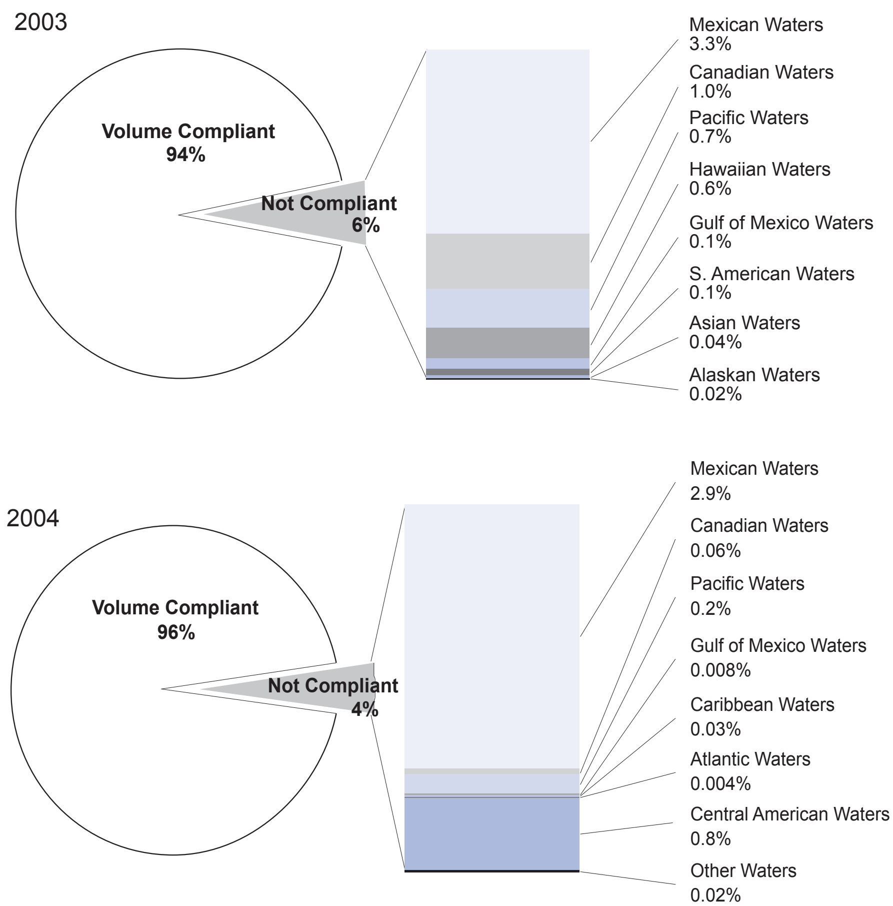
Number of vessels that reported discharging ballast water in California waters compared to the number of vessels that reported no discharges.



Note: Reporting requirements changed in 2004, resulting in a much larger number of reporting forms sent to the CSLC.

Volume-Based Ballast Water Management in 2003 and 2004

A total of 15 million metric tons (MT) of discharged ballast water was reported statewide in 2003, and 7.8 million MT was reported in 2004. In both years, over 90% complied with state law. Sources of non-compliant ballast water are illustrated.



Note: Reporting requirements changed in 2004, resulting in a change in the number and nature of reports submitted to the CSLC.

DWR also participates in programs aimed at controlling invasive weeds along eroding Sacramento River banks, within flood control and water conveyance structures, and along urban streams. The agency coordinates its activities with other state and federal agencies as a member of the CALFED Non-native Invasive Species Advisory Council.

The State Water Resources Control Board, and its nine regional water quality control boards have no specific policies and programs related to AIS but have been working in support of, and in an advisory capacity to, other state agencies on various related activities such as hull fouling and ballast water management. Invasives come under water board purview as part of the state's efforts to implement and enforce the Clean Water Act (CWA, see also Appendix B). A 2005 federal court ruling defining non-indigenous species as "pollutants" present in discharges from vessels, and finding that such discharges are not exempt from permitting requirements (NPDES, see also CWA, Appendix B). In terms of AIS management activities, some of the regional boards have also sought to place specific water bodies within their regions on the CWA's 303(d) list, as impaired by exotics. S.F. Bay was listed in 1998. In 2006, the State Board will consider listing proposals for the Delta, the upper San Joaquin River and the Cosumnes River. Once on the 303(d) list, the regional boards are required to develop discharger/source based programs for managing pollutant loads (called TMDLs), which in the case of exotics has proved somewhat difficult to develop. Trying to allocate loads, or goals for zero loads, among dischargers, water users and municipalities is challenging when most of the water bodies in question are already heavily invaded. Despite the implementation challenges, the S.F. Bay board's work on the state's first exotics TMDL did, however, widely publicize the problem and led to other successful AIS management and legislative programs. Other regional boards have become involved in AIS-related water quality issues through watershed management projects, non-point source pollution management programs, and wetland mitigation and restoration programs (raising issues about the use of non-native aquatic plant species for these programs, and the control of invasives, for example). The State Board has also participated in AIS management activities concerning the use of aquatic pesticides.

Figure 7: Primary State Agencies & Activities

FIGURE 7: PRIMARY STATE AGENCIES & ACTIVITIES

Agency	Contact	Vectors	Species
California Department of Boating and Waterways	Deputy Director: David Johnson AIS Staff: Marcia Carlock mcarlock@dbw.ca.gov (916) 263-8142 http://www.dbw.ca.gov/	Recreational boating	Water hyacinth Brazilian elodea (egeria)
California Department of Fish and Game	Branch Chief: Kevin Hunting AIS Staff: Susan Ellis sellis@dfg.ca.gov (916)653-8983 http://www.dfg.ca.gov/ http://www.dfg.ca.gov/ospr/ http://www.dfg.ca.gov/ospr/organizational/scientific/exotic/MISMP.htm	Aquaculture Live fish and animal transportation and imports	Fish Aquatic organisms and plants Algae (*Caulerpa*)
California Department of Food and Agriculture	Branch Chief: Robert Leavitt AIS Staff: Pat Akers pakers@cdfa.ca.gov (916)654-0768 http://www.DFA.ca.gov/	Aquaria Nurseries Agriculture	Hydrilla and other aquatic weeds Agricultural pests
California State Lands Commission	Branch Chief: Gary Gregory AIS Staff: Maurya Falkner falknem@slc.ca.gov (916)574-2568 http://www.slc.ca.gov/Division_Pages/MFD/MFD_Programs/Ballast_Water/Ballast_Water_Default.htm	Ballast water Hull-fouling Commercial shipping	Marine invasives eurasion water milfoil
California Department of Water Resources	Branch Chief: Richard S. Breuer AIS Staff: Tanya Veldhuizen tanyav@water.ca.gov 916)227-2553 http://www.water.ca.gov/	Water supply and delivery systems Flooding	Riparian weeds Mitten crab Aquatic food web
The State Coastal Conservancy	Executive Officer: Sam Schuchat AIS Staff: Abe Doherty adoherty@scc.ca.gov (510)286-4133 http://www.coastalconservancy.ca.gov/	Coastal preservation restoration	*Spartina* *Arundo* Wetland invasives
State Water Resources Control Board	AIS Staff: Kim Ward kward@waterboards.ca.gov (916) 341-5586 http://www.swrcb.ca.gov/ http://www.waterboards.ca.gov/nps/5yearplan.html/	Discharges Runoff	General exotics

For detailed information on these and other state, federal and local agencies involved in AIS management see Appendices B, C & D.

Partnerships with NGOs, Business and User Groups

Many AIS management activities are undertaken through partnerships with local groups and organizations, or by non-governmental organizations (NGOs), private landowners and various interest groups. Those currently active range from large environmental and land-holding organizations such as the Nature Conservancy and country land trusts to smaller watershed, tribe, or special interest groups (fishing, hunting, boating etc.) and business groups affected by AIS management activities (shippers, aquarium trade, etc.). A number of task forces and projects are dedicated to very specific invaders such as *Arundo donax* and *Giant Salvinia* (see Appendix D). Such groups and organizations can greatly help state and federal efforts to manage AIS.

Partnerships with Universities, Research Institutes, and Consulting Firms

Increased knowledge of the biology and ecology of invasive species and associated control methods will allow for the most effective management of AIS in California. Research is needed to quantify and clarify the effects that non-native species are having on native plants and animals and their habitats. It is also important to know what economic effects AIS are having and whether there are any human health and safety concerns resulting from an infestation. Partnerships with universities, research institutes and consulting firms are needed so that agencies can develop their management programs with scientific input.

SUMMARY OF CALIFORNIA LAWS, REGULATIONS & AUTHORITIES

The primary authority for state efforts to prevent AIS introduction and manage the spread and impacts of AIS in state waters derives from California's Fish and Game Code, and Food and Agriculture Code, and from the Ballast Management Act of 1999 and the Marine Invasive Species Act of 2003. Various federal laws also impact management activities. For a more comprehensive description see Appendices B & C.

California Fish and Game Code & Title 14 of Code of Regulations

At least five code sections address or relate to aquatic invasive species, restricting or limiting in various ways: the impacts of AIS control measures on state listed species; the importation and transportation of restricted live wild animals and plants; the placement of live fish, fresh or saltwater animals or aquatic plants in any state waters of this State; and the operation of aquaculture industries. The code also prescribes state surveys of ballast water-related invasive species. Most of these regulations are enforced by DFG.

F& G Code §§ 2080–2089, 2118, 2270-2272, 6400-6403, 6430-6433: 15000 et seq.
http://www.fgc.ca.gov/html/regs.html
http://www.dfg.ca.gov/ospr/organizational/scientific/exotic/exotic%20report.htm.

California Food and Agriculture Code

Over 30 different code sections address the state's mandates to prevent the introduction and spread of injurious animal pests, plant diseases and noxious weeds. These codes describe procedures and regulations concerning, among other things, plant quarantines; emergency pest eradications to protect agriculture; pests as public nuisances; vectors of infestation and infection; the sale, transport and propagation of noxious weeds; and the protection of native species and forests from weeds. Most of these regulations are enforced by DFA.

F & A? Code §§ 403, 461, 5004, 5021-5027, 5301-5310, 5321-5323, 5401-54204, 5421, 5430-5432, 5434, 5761-5763, 7201, 7206-7, 7501-2
www.leginfo.ca.gov

California Water Code

The Porter-Cologne Water Quality Control Act (California Water Code, Division 7) lists a number of types of pollutants that are subject to regulation. Section 13050, for example, specifically includes the regulation of "biological" pollutants by defining them as relevant characteristics of water quality subject to regulation by the Board: AIS are an example of this kind of pollutant if they are discharged to receiving waters. The Water Code generally regulates more substances occurring in discharges, and also defines discharges to receiving waters more broadly than the federal Clean Water Act.

Water Code §13050

Harbors & Navigation Code

This code authorizes DBW to manage aquatic weeds impeding the navigation and use of state waterways.

Article 2, Section 64

Ballast Water Management Acts (AB 703 and AB433)

The Ballast Management for Control of Nonindigenous Species Act of 1999 created the state's first program to prevent non-indigenous species introductions through the ballast water of commercial vessels. The act required that vessels originating from outside the United States Economic Exclusive Zone carry out mid-ocean exchange or use an approved ballast water treatment method, before discharging in California state waters. State enforcement of the act took the form of monitoring ballast discharges and reports, inspecting vessels for compliance, and assessing vessel reporting rates and compliance.

Upon the sunset of the Act, the Marine Invasive Species Act (AB433) was passed in 2003, widening the scope of the original program. The 2003 act requires ballast water management of all vessels that intend to discharge ballast water in California waters, though the regulations differ depending on voyage origin. All qualifying vessels coming from ports within the Pacific Coast region must conduct near-coast exchange (in waters at least 50 nautical miles offshore, and 200 meters deep), or retain all ballast water and associated sediments. All vessels must complete and submit a ballast water report form upon departure from each port of call in California. They must also comply with the good housekeeping practices, ranging from avoiding discharge near marine sanctuaries to rinsing anchors and removing fouling organisms from the hull. They must also keep logs of ballast management activities, conduct crew training, and pay a fee for each qualifying voyage at their first port of call in California. To determine the effectiveness of the management provisions of the act, the legislation also requires state agencies to conduct a series of biological surveys to monitor new introductions to coastal and estuarine waters.
PR Code §§ 71200-71271; CC 2271
http://www.slc.ca.gov/Division_Pages/MFD/MFD_Programs/Ballast_Water/Ballast_Water_Default.htm

Regulated Species
For a list of AIS plant and animal species regulated by the state see Appendix G.

PRIMARY FEDERAL AUTHORITIES & AGENCIES

California's AIS management efforts must also be coordinated with the federal government's extensive efforts on the same front. No single federal agency has comprehensive authority for all aspects of aquatic invasive species management. Federal agencies with regulatory authority over the introduction and transport of aquatic species that may be invasive or noxious include the U.S. Department of Agriculture Animal Plant Health Inspection Service, the U.S. Department of Agriculture Agricultural Marketing Service, the U.S. Fish and Wildlife Service, the U.S. Department of Commerce, and the U.S. Coast Guard. But many other agencies have programs and responsibilities that address components of AIS, such as importation, interstate transport, exclusion, control, and eradication.

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) established the first major federal program to prevent the introduction and control the spread of introduced aquatic nuisance species. The act provides an institutional framework that promotes and coordinates research, develops and applies prevention and control strategies, establishes national priorities, educates and informs citizens, and coordinates public programs. The act also calls upon states to develop and implement comprehensive state AIS management plans, such as this California plan. In 1996, the National Invasive Species Act (NISA) amended the 1990 Act to mandate ballast water exchange for vessels entering the Great Lakes and to implement voluntary ballast water exchange guidelines for all vessels with ballast on board that enter U.S. waters from outside the Exclusive Economic Zone (EEZ). The Act also authorized the Coast Guard to toughen requirements if compliance proved unsatisfactory, which it did in 2004. As a result, the Coast Guard has since established mandatory ballast water management requirements for all ships entering U.S. waters and penalties for non-compliance.

Under NANPCA/NISA, states are specifically permitted to regulate ballast water on ships. Several states have elected to do so to various degrees. In addition to reporting requirements, California, Oregon and Washington have ballast water exchange requirements and California law requires the state to issue a ballast water discharge standard in 2007.

The Executive Order on Invasive Species signed by President William J. Clinton on February 3, 1999, expanded federal efforts to address AIS. The order intended to build upon existing laws, such as the National Environmental Policy Act, the Nonindigenous Aquatic

Nuisance Prevention and Control Act, the Lacey Act, the Plant Pest Act, the Federal Noxious Weed Act, and the Endangered Species Act. The order creates a National Invasive Species Council charged with developing a comprehensive plan to minimize the economic, ecological, and human health impacts of invasive species and determine the steps necessary to prevent the introduction and spread of additional invasive species. Federal activities are now coordinated through this council and through the National Aquatic Nuisance Species Task Force.

Beyond authorities and legislation, some of the other major federal activities related to AIS management in California include:

- USFWS' 100th Meridian Initiative to stop the zebra mussel from spreading west.
- NOAA's Sea Grant Program, and its support for the West Coast Ballast Outreach Project (which educates the maritime industry about the ecological seriousness of aquatic exotic species), as well as funding for research on key invasive species.
- USDA's federal noxious weed list, maintained through the APHIS Cooperative Agricultural Pest Survey, and it's Agricultural Research Service (ARS) units at Davis and Albany, California, whose work includes improving management of invasive aquatic and riparian weeds affecting agriculture and natural resources;
- USEPA's recent commitment to providing federal coordination for AIS rapid response planning and associated permitting.
- USGS ongoing research and data bases on invasive species.

For detailed information on federal AIS authorities, agencies and programs, see Appendix B or visit http://www.anstaskforce.gov and www.invasivespecies.org

Coordinating Framework

The previous section demonstrates how AIS activities are spread across multiple state agencies. Managers working on AIS from the various agencies have been coordinating activities on specific AIS issues though a variety of venues and networks. However, this coordination has not taken place on a holistic level due to the lack of a formal coordinating framework for AIS. This section will describe the coordinating framework proposed in this plan. The actions related to creating this framework are listed in Chapter VI under Objective 1. This framework will allow for the comprehensive assessment of AIS activities and ensure action on high priority activities.

The first step will be to develop an executive level consultation process for state agencies involved with AIS management. This could be accomplished by regular briefings to agency and department directors by key state AIS managers. The formation of an AIS or Invasive Species Council made up of department and agency upper management would provide a venue for coordination and consultation at the executive level. In the absence of an AIS or Invasive Species Council, coordination could be accomplished through the California Biodiversity Council. In addition, briefing should be made to the Ocean Protection Council. Coordination and consultation at the executive level is critical to provide policy level direction and planning for the State that includes legislation, funding, and program direction for all state departments responsible for addressing invasive species issues.

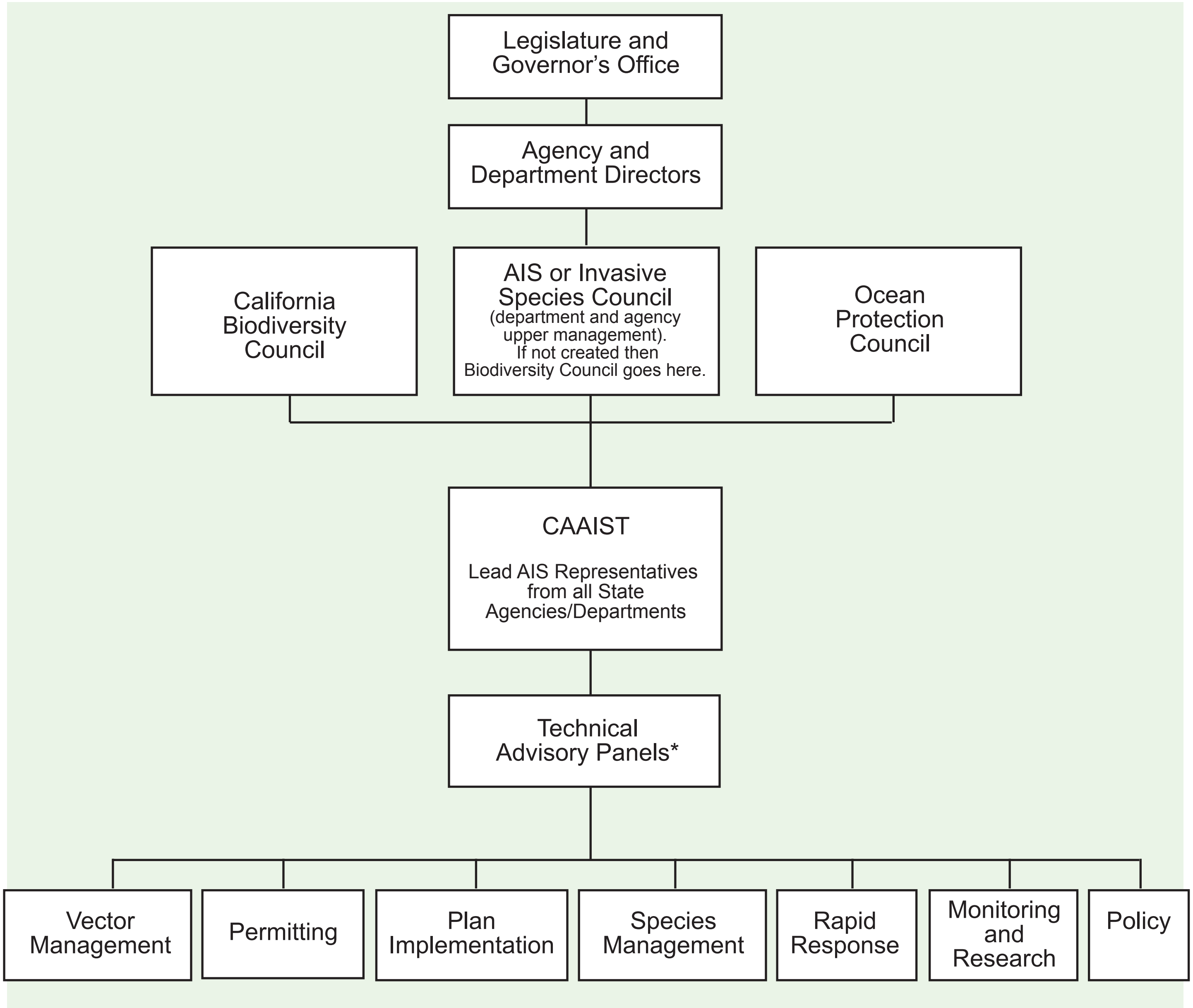
The core of the coordination framework is the California AIS Team (CAAIST). This team is made up of the lead representative for AIS from each state agency and/or department (see Figure 7). The team will be led by DFG's State Invasive Species Coordinator. Although this team has met informally in the past, the group will be formalized and meet on a regular basis to oversee implementation of the state AIS plan. To get the needed executive level action to implement the plan the CAAIST members will report to the Executive Chiefs of their agency/department and report to councils that address invasive species issues, including the Biodiversity Council, the Ocean Protection Council, and an AIS or Invasive Species Council (if formed).

CAAIST will form technical advisory panels to obtain guidance on specific issues within plan. The technical advisory panels will be ad hoc and meet on an as needed basis. Activity of the panels will vary with respect to the needs of the CAAIST and the implementation schedule outlined in the plan. In addition to state agency staff, the panels will be made up of representatives from the following groups: federal agencies, local agencies, research institutions, NGOs, Native American organizations, and stakeholders. Examples of the types of technical advisory panels that will be formed will include, but are not limited to, the following: Plan Implementation, Permitting, Species Management, Rapid Response, Monitoring and Research, Policy, and Vector Management.

This coordinating structure is an important component of state AIS management program. There will now be a formalized group where AIS management issues can be presented and discussed and critical gaps identified and addressed. The technical advisory panels will provide forums for input from federal agencies, local agencies, research institutions, NGOs, Native American organizations, and stakeholders. An executive level consultation process will allow agencies to develop policies, obtain funding, and have program direction needed for addressing aquatic invasive species.

Figure 8: California AIS Coordinating Structure

FIGURE 8. AIS COORDINATING STRUCTURE



* Technical Advisory Panels will be made up of representatives from federal agencies, state agencies, local agencies, research institutions, NGOs, Native American organizations, and stakeholders, as appropriate.

Gaps & Challenges

Factors such as lack of communication, legal loopholes and shortfalls, and unique water delivery and geographic conditions complicate California's efforts to prevent and manage invasives species introductions. California, like other states, suffers from the following challenges to effective AIS management:

- Difficulty in balancing negative environmental impacts of chemical treatment with positive protection of native habitats and listed species.
- Difficulty in timely permitting for rapid response, eradication and control.
- Lack of adequate long-term funding.
- Difficulty coordinating diverse state activities, agencies and programs, and ensuring communication and high-level priority setting to optimize limited management resources.
- Lack of awareness of, and enforcement of, existing laws
- Limited detection and treatment technologies, and coordination among detection efforts.
- Limited public awareness of the threats posed by, and costs of managing, AIS versus the threats from pesticides used to control them.

This management plan is a substantial step toward addressing these challenges. It emphasizes coordination, communication and prevention, suggests actions and legislation to fill management gaps and provides a foundation for California's first comprehensive state-wide approach to AIS.

V. CASE STUDIES IN ERADICATION & CONTROL

1. RAPID RESPONSE IN SAN DIEGO: CAULERPA

Invasion: *Caulerpa taxifolia* is a marine alga native to the warm waters of the Red, Indo-Pacific, and Caribbean seas. The bright-green plant, which has feathery, fern-like fronds extending upward from a main stem, is fast-growing and easy to cultivate. *C. taxifolia* gained popularity as an aquarium plant in the 1970s. In the early 1980s a strain of *C. taxifolia* that had adapted to temperate waters escaped from Germany's Stuttgart Aquarium into the northern Mediterranean. By 2001, the temperate strain of *C. taxifolia* carpeted more than 30,000 acres of coastal waters from Spain to Italy, moved into the Croatian Adriatic,and from there, spread to Northern Africa. As the plant spread, it excluded native plants and animals.

It took nearly twenty years for *C. taxifolia* to make a colonization attempt in the New World. In July 2000, biologists conducting an eelgrass restoration project in Carlsbad, California, near San Diego, found monoculture patches of *C. taxifolia* covering approximately 1,100 square meters of a coastal estuary known as Agua Hedionda Lagoon. The resulting press coverage brought attention to a previously known second infestation of scattered individual plants over seven acres of Huntington Harbor in Huntington Beach, near Los Angeles. Genetic tests confirmed that both areas had been invaded by clones of the aquarium strain, suggesting aquarists had dumped the contents of their saltwater tanks into California waters.

Concern: *C. taxifolia* is one of the world's most notorious marine invasives. Though tropical in origin, the clone cultivated in home aquaria has adapted to waters as cool as 50 degrees F. The aquarium strain can grow in rock, sand, and mud, and reproduces at the rates as high as half an inch per day, growing in monoculture patches that are both taller and more vigorous than its wild ancestor, which is genetically distinct from the aquarium strain and is not known to be invasive. Sexual reproduction has not been documented but *C. taxifolia* reproduces easily, regenerating from small fragments broken off from the main plant. *C. taxifolia* is not particularly vulnerable to predation. Chemicals in its tissues make it unpalatable to most animals. In the laboratory, *C. taxifolia* has survived a wide array of kill techniques, including high doses of herbicides and algicides as well as light exclusion for more than one month.

Response: The plant's notoriety helped galvanize an immediate response to the California infestations. Plant samples taken from Agua Hedionda Lagoon were identified literally overnight as *C. taxifolia*. A task force consisting of representatives from more than ten state, federal, and local agencies plus local stakeholders and experts met within days to determine how to manage the outbreaks. Given the speed with which *C. taxifolia* had invaded the Mediterranean, and the ecological havoc that ensued, the task force approved a plan calling for an immediate eradication response. Regulatory agencies agreed in advance to green-light permits for eradication work to begin within two weeks.

Both infestations occurred in bodies of water with restricted ocean access. This enabled kill procedures to take place in areas sheltered from ocean waves, and made surveys for regrowth safer and easier to conduct. In Agua Hedionda, divers surveyed the lagoon and mapped patches of the alga. The patches were covered by tarpaulins and the edges secured by sandbags and rebar. Solid chlorine pucks were placed beneath the tarps to make up a five percent bleach solution. Before the tarpaulins were lifted, sediment cores were grown out in the laboratory to determine whether any viable *C. taxifolia* remnants remained. Meanwhile, teams of divers continuously resurveyed the 200-acre lagoon to ensure no other plants had been missed. A similar tarp, bleach, and survey protocol was followed at Huntington Harbor. The last specimens of *C. taxifolia* were found outside the tarpaulins at both sites in fall of 2002. The alga was officially declared eradicated in July 2006. All told, the eradication effort cost $7.7 million, including planning, field work, monitoring, and reports.

Lessons: Several factors contributed to the success of *C. taxifolia* eradication in southern California. Rapid identification, an expedited process, and cooperation among stakeholders, plus adequate funding and follow-up, all contributed to eradication. Biologists were aware of *C. taxifolia's* invasion of the Mediterranean and rapidly identified the problem. Concern over a similar outbreak in California spurred the prompt formation of an invasion task force. Stakeholders were identified within days and agreed to participate in response plan discussions. The specter of the alga's escape prompted task force members to aim for eradication despite the fact that some native species, such as eelgrass and estuary invertebrates, would be harmed. Team members divided tasks, some turning their full attention to eradication while others concentrated on permitting applications and approval. Regulatory agencies agreed to cooperate with the eradication plans and expedite permitting. Financing was adequate to maintain a sustained response. Intensive monitoring surveys were conducted for least three years to guard against any regrowth.

2. ERADICATION EFFORT IN THE SAN FRANCISCO BAY ESTUARY: SMOOTH CORDGRASS

Invasion: Intentionally introduced to the San Francisco Bay Estuary in the 1970s to stabilize shorelines, smooth cordgrass (*Spartina alterniflora*) spread rapidly, hybridized with Pacific cordgrass (*Spartina foliosa*), and today threatens thousands of acres of tidal marshes and restoration projects around the Bay. In 2000, surveyors tallied 470 acres of hybrid smooth cordgrass, while the original introduced parent had become quite rare. By 2003, the hybrids covered 2000 acres. But the *Spartina alterniflora* was not confined to certain areas; the invader was widely dispersed through 69,000 acres of tidal marsh and mudflats and had invaded every marsh restoration project in the Bay.

Concern: The hybridization between smooth and Pacific cordgrass resulted in a large amount of genetic variation, which allowed individual plants to survive in different parts of the marsh and to exploit open niches. Some hybrids grow well in higher marsh elevations while others flourish on open mudflats. In order to adapt to varied conditions, hybrid smooth cordgrass can produce up to 23 times the seed as native cordgrass, grow taller and/or faster, and tolerate high or low salinity. The hybrid cordgrass tends to grow in dense stands. By turning diverse marshes into monocultural meadows, the hybridized cordgrass crowds out the meandering tidal channels used by the endangered California clapper rail and other native salt marsh species, and reduces habitat for fish and shellfish. This invasion sequence can transform open mudflats into huge, uniform expanses of cordgrass, destroying foraging habitat for migratory and resident shorebirds. Flood control channels are also threatened by this invasion, as the cordgrass has the ability to significantly impede flow with increased siltation rates and biomass accumulation.

Response: In 2000, the Coastal Conservancy began to organize a multi-agency, region-wide control effort in the San Francisco Estuary called The Invasive Spartina Project (ISP). With substantial funding from the CALFED Bay Delta Program, the ISP surveyed and mapped the invasive cordgrass, evaluated a wide range of potential treatment strategies and methods, prepared environmental review documents under CEQA and NEPA, developed extensive partnerships with regional marsh owners and managers, obtained necessary permits (e.g., ESA Section 7 and CWA Section 402/NPDES), and prepared site-specific treatment plans for over 130 known infested marshes. The ISP also coordinated funding flows from CALFED through the Coastal Conservancy to the land owner/manager partners. In 2004, ISP partners initiated treatment efforts, which consisted of spraying selected infested marshes with glyphosate (Aquamaster(r), the aquatic version of Roundup(r)), and using light mechanical removal methods.

The ISP faced a number of constraints as it attempted to respond to the fast-moving invasion of hybridized *S. alterniflora*. Mechanical removal methods, such as mowing, sometimes aggravated the problem. Spraying was slow, dirty work. It had to be limited to days with no rain, and with low wind and periods of low tides, so as to minimize drift issues and keep the herbicide from washing off of the surface of the plants. Targeted plants had to be entirely coated with the glyphosate herbicide to achieve maximum efficacy, which in most cases proved to be around 50% at best. Another problem was that glyphosate tends to become deactivated when it binds with sediment; since Bay water contains a great deal of suspended sediment which is deposited on the cordgrass twice daily, much of the applied herbicide was rendered inactive before it even entered plant tissue.

To add to the difficulty, herbicide application had to take place in the late summer before the plants set seed and go dormant, but also had to be scheduled so as not to interfere with the breeding season of a federally endangered California clapper rail (February through August). Mowing and other mechanical removal methods could not be used in marshes frequented by the clapper rail.

In November 2004, the ISP and the US Environmental Protection Agency hosted the Third International Conference on Invasive Spartina, where the ISP shared its experiences with *Spartina* experts from around the world. At this meeting, the ISP requested guidance regarding the feasibility and approach to controlling the hybrid cordgrass invasion. Conference participants were impressed by the level and complexity of the invasion problem, and advised that control could potentially be achieved if the ISP proceeded immediately with an aggressive regional control program.

Before such a program could get underway, surveys for California clapper rails in the infested marshes had to be performed, as well as an analysis of the potential impacts of treating each site where the rail was present. The ISP partnered with Point Reyes Bird Observatory, Avocet Research, the East Bay Regional Parks District, the U.S. Fish and Wildlife Service, and DFG to conduct coordinated annual Bay-wide clapper rail surveys. The results of this effort directly informed the treatment approaches identified by the control program of the ISP.

In 2005, the ISP targeted 132 infested areas, with a goal of treating 70-80 percent of the infestation in that year. The ISP began using a new herbicide, imazapyr (Habitat(r)), which had been registered for use on August 30, 2005 in California but known to be highly effective in eradicating invasive cordgrass in Willapa Bay, Washington. Imazapyr has several advantages over glyphosate. It does not require a 6-12 hour post-application period without tidal inundation, it is less toxic to aquatic organisms than glyphosate, and it can be used more sparingly, with greater success. One drawback is that it can damage non-target plants if it is over-sprayed, though preliminary observations of treated sites show normal seasonal regrowth of native marsh plants such as pickleweed (*Salicornia*).

In 2005, imazapyr was applied to 1,010 acres of invasive cordgrass, sprayed from amphibious tracked vehicles, helicopters, airboats, backpacks, and trucks working from levees. Applicators estimate that the new herbicide, with less spray volume required, increased the efficiency of treatment by as much as one-third over glyphosate. Preliminary assessment in the spring of 2006 indicated that the 2005 imazapyr treatments killed up to 80% of the targeted plants. Based on these results, the ISP now envisions that, given continued adequate funding, non-native cordgrass will be effectively eradicated from the San Francisco Estuary within the next several years.

In addition to working toward getting the invasion under control, the ISP continues to prepare environmental documents and obtain permits as needed, conduct research and annual inventories, and work to ensure continued funding. The ISP and affected resource agencies are also starting to develop an "exit strategy" for the ISP, whereby long-term monitoring and treatment responsibilities will be turned over to a network of informed land managers around the S.F. Bay Estuary, who have themselves participated in significant control work on their lands.

Lessons: Years of frustrated attempts by individual landowners to manage invasive cordgrass on their properties demonstrated the need for a coordinated regional approach. Landowners could not control reinfestation from adjacent properties and had nearly given up by the time the Coastal Conservancy initiated efforts through the ISP. Even then, delays in getting the treatment program underway were nearly fatal to the effort. At the outset of the ISP in 2000, non-native cordgrass infestation in the Bay was roughly one-third the area mapped in 2005. In the five years it took to develop the necessary budgeting, permitting, and scientific framework to comprehensively tackle the problem, the infestation grew significantly. Because of substantial and reliable support from the Conservancy, the CALFED Bay Delta Program, the Bay Area environmental community, and regional land managers, the ISP was able to adapt to the expanding scope of the problem, despite setbacks suffered along the way.

One of the most difficult aspects of controlling an invasive species in a region that is highly urbanized and carefully monitored for its unique environmental value, is coming up with a sufficiently rapid response. Environmental regulation around sensitive tidal marshlands had been instituted in response to urban growth, or, in some cases, was designed to reflect specific issues: endangered species protection, or water use. By contrast, the cordgrass invasion in the Bay encompassed multiple jurisdictions, habitat types, developmental zones, political mindsets, animal and plant species, and levels of enthusiasm. Currently there is no overarching mechanism to cut through the permitting process for an effort that is, in essence, aimed at controlling the rapid spread of a biological pollutant, and enhancing and maintaining the health of the environment. The experience of the ISP shows that in a perfect situation, where the budgetary, political and environmental stars align, a weed-control project can succeed despite the significant burden of regulation. However, when that kind of alignment is absent, worthy projects of lesser scale would likely be unsuccessful, or worse yet, not even get off the ground. The best analogy may be that of a war, when it is often desirable to strike quickly, before much ground is lost.

3. CONFOUNDING COMPLICATIONS IN THE DELTA: EGERIA DENSA

Invasion: *Egeria densa* (Brazilian elodea) is a fast-growing shallow-water submerged aquatic plant that now infests approximately 12,000 acres of the 50,000 surface acres of the San Joaquin/Sacramento River Delta (Delta). *E. densa*, a native of Brazil and Argentina, has also become widespread in New Zealand, Australia, Japan, and Chile. In the U.S., *E. densa* has invaded lakes and ponds along the western coast from Washington to California, through the South, and as far north as New Hampshire and Vermont in the Northeast. *E. densa*, which has individual strands that resemble a long, furry brush, was identified in the Delta approximately 40 years ago. It is believed that *E. densa* was introduced by cleaning an aquarium and discarding the plant into the Delta.

The first recorded complaints by boaters in the Delta about *E. densa* mats impeding navigation are from 1988. The initial infestation appeared limited to a relatively small area. In 1999 aerial surveys indicated *E. densa* covered approximately 4,000 surface acres, or about eight percent of the Delta. Six years later, in 2005, *E. densa* coverage had tripled to 12,000 acres, or about 24 percent of the Delta. *E. densa* is estimated to be spreading at a rate of about 1,000 acres per year. Some of the most heavily infested areas of the Delta are Rhode Island, where almost the entire 66 acres of the island are covered, and Franks Tract State Recreation Area, where approximately 700 acres of approximately 900 acres are covered. Thousands of acres of the Delta remain at risk; much of the ecosystem consists of freshwater areas less than 10 feet deep, the habitat in which *E. densa* thrives.

Concern: True to its name, *E. densa* grows in subsurface mats that can be several feet thick. *E. densa* is a visible and immediate problem for boaters, but an *E. densa* infestation also has a host of broader impacts. *E. densa* can obstruct waterways, forcing boaters to stop frequently to clear propellers, or, in more extreme cases, preventing passage of large and small vessels. The plant can also impede migration of anadromous and pelagic fish. *E. densa* changes the architecture of shallow water ecosystems, forming walls between deepwater and inter-tidal habitat. Impenetrable mats of *E. densa* can force fish such as salmon and Delta smelt into more open waterways, where food resources may be scarce and where fish are more vulnerable to predators. The mats of *E. densa* can also impede water flows, crowd out native plants, entrap sediments, and clog agricultural and municipal water intakes.

Response: Legislative delays, treatment complexity, and conflicts between herbicide application and native species protection have all been ongoing problems in the effort to eradicate *Egeria densa*.

The initial response to the *E. densa* invasion was not rapid. Complaints of waterway obstruction by *E. densa* went on for nine years before state legislation authorizing the Department of Boating and Waterways to address the invasion passed in 1997. Two additional years passed before the legislature authorized funding to study *E. densa*. During this period, *E. densa* continued to expand its niche in the Delta. A plant that had once been a localized nuisance soon became the most widespread aquatic weed in the Delta.

Once it was authorized to deal with the problem, DBW explored many different treatment and control options. These included a variety of herbicide types as well as mechanical harvesting. Department officials discovered that the harvesting of *E. densa* causes fragments to escape and freely float to new areas where they can take hold and sprout new growth somewhere elsewhere. Mechanical harvesting's unintended consequences made it a tool only to be used in an emergency.

Herbicides based on chelated copper have proved the most effective at destroying *E. densa*. Chelation helps prevent copper from entering the food web, and causes preferential binding to sediments instead. However, concerns over adding more heavy metals to the Delta forced DBW to turn to another herbicide, fluridone.

Fluridone treatment had its share of problems, too. The herbicide is most effective against *E. densa* during the growth cycle of the plant. The peak growth period for *E. densa* is in early spring. However, spring in the Delta coincides with the spawning and in and out-migration of several protected species in the Delta, including Chinook salmon, *Oncoryhnchus tshawytscha*, (out migration), steelhead trout, *Oncoryhnchus mykiss*, (in-migration, spawning and out-migration), delta smelt, *Hypomesus transpacificus*, (spawning) and the proposed listing of the green Sturgeon, *Acipenser medirostris*, (spawning).

Federal agencies, including NMFS and USFWS have requested numerous toxicity tests to ascertain whether fluridone is harmful to these species. Research thus far has confirmed that the concentrations of the herbicide fluridone used to treat *E. densa* does not harm these species. For example, Chinook salmon fingerlings showed no toxic effects below concentration levels used by the DBW. However, continued concern over the health of migrating and spawning species has led to limitations in fluridone treatment timing.

During the 2001 treatment season, DBW applied the herbicide during the summer months of July through September instead of during the optimum time frame of April through June as recommended by the manufacturer and other scientific studies. While the herbicide did prevent proliferation of some of the *E. densa*, it failed to substantially reduce the total acreage covered.

Monitoring during applications has been extensive. The fluridone treatments at each site are monitored using immunoassays analyzed to ensure applications are occurring at an efficacious rate and are within all published (agricultural and municipal) limits. The immunoassays are collected within the treatment area, the receiving waters and at all agricultural and municipal water intakes on a bi-weekly basis. DBW also takes water samples and monitors water quality of the treatment area to comply with its NPDES General Permit.

In 2005, NOAA Fisheries agreed for the first time to permit *E. densa* treatment to begin in spring in a few select sites. The new treatment schedule proved extremely effective. At one site, the treatment appears to have eliminated populations of *E. densa*, suggesting fluridone may only need to be applied in the future every second or third year to maintain control of the plant.

Treatment success has been measured using two new and innovative methods. The plant grows in dense mats just below the surface of the water, where it is difficult to determine whether treatments have had an effect. The DBW uses hydroacoustic measurements to determine bio-mass/volume of the plants prior to and after treatments have occurred. In addition, a new technique known as Hyperspectral analysis now permits more refined estimates of *E. densa* coverage in the Delta. Each type of plant species, including *E. densa*, produces a unique spectrum of infared reflectance. Aerial images of the Delta are taken before and after treatment using digital broad spectrum photographs. The light wavelengths captured in these images are then analyzed to determine a percentage of *E. densa* in a given waterway. Some analysis has been completed on water-milfoil, pepperweed, and purple loosestrife, as well. DFA, DFG, and DBW have all used Hyperspectral analysis to measure the extent of coverage for these plants and other species since 2002.

In 2005, DBW treated 14 sites comprising 648 acres. The relatively small area reflects treatment crew limitations and other restrictions placed on the program. Additional funding for application crews and continued easing of restrictions on start dates could enhance the DBW *Egeria Densa* Control Program.

Lessons: First, delays in early identification, authorization, and funding permitted *E. densa* to expand from a local waterway nuisance to an invasion widespread throughout the Delta. Second, new analysis tools have allowed scientists to gather basic data about the plant's growth characteristics and response to herbicide application. The information should help managers fine-tune future treatment methods. Third, while toxicity testing is critical to prevent damaging resident wildlife populations, it should be balanced against the need to control an invader proven to have devastated habitats elsewhere.

4. STRATEGY FOR TAHOE BASIN: EURASIAN WATERMILFOIL

Invasion: Eurasian watermilfoil was first thought to occur on the south shore of Lake Tahoe in 1975. By 1980, it became well established in the Tahoe Keys, which is a large marina complex on the south shore built out of a marshland. From 1994 to 1997 USDA-ARS confirmed the presence of Eurasian watermilfoil outside the Keys and found it to be spreading rapidly elsewhere in the Lake. In 1997, it was reported that out of 200 acres of Eurasian watermilfoil in Lake Tahoe, 170 acres were in the Tahoe Keys. Aerial and boat surveys since 1995 indicate the plant continues to spread to new locations in the nearshore zone and has established itself in several marinas and other natural areas including Emerald Bay, which is leased to the California Department of Parks and Recreation as an underwater park. In addition to Eurasian watermilfoil, an equally aggressive aquatic weed, curly-leaf pondweed (*Potamogetan crispus*), has recently been detected in Lake Tahoe.

Concern: Eurasian watermilfoil and other invasive aquatic weeds grow prolifically and aggressively invade native aquatic plant communities. Native aquatic plant communities provide many ecological benefits such as food and habitat for waterfowl, fish, and other aquatic organisms. They also help maintain water quality by absorbing nutrients, providing oxygen, and reducing shoreline erosion. However, when Eurasian watermilfoil is introduced it is able to dominate fresh water ecosystems quickly when fragmented by boat propellers and by way of buds and surface runners. It also tolerates a wide range of environmental conditions including low light levels, high or low nutrient waters, and freezing water temperatures. Eurasian watermilfoil also begins to create its own habitat by trapping sediment and initiating a favorable environment for further establishment. For these reasons, Eurasian watermilfoil can aggressively out-compete and eliminate native aquatic plants.

Aquatic weeds in Lake Tahoe impact several of Tahoe Regional Planning Agency (TRPA) thresholds including water quality, fish habitat, vegetation, and recreation. Impacts pushing the limits of these thresholds include accelerated nutrient cycling, contributing to algae growth and decreased water clarity; lost or impaired fisheries habitat, including feed and cover; threats to native aquatic vegetation; and restrictions boating, water skiing, fishing, and swimming due to dense matting (this species is known to cause drowning deaths in other areas of the U.S.).

Response: In 2002, the Lahontan RWQCB began providing fact sheets to interested parties and agencies to promote awareness of Eurasian watermilfoil in Lake Tahoe, share information about options for controlling the growth and proliferation of this weed, and present the regulatory requirements applicable to weed management activities. Because Lake Tahoe is a bi-state water of the U.S. that has been federally adopted as an Outstanding National Resource Water, Lahontan RWQCB has taken the position that chemical treatment to control invasive aquatic weeds is not justified at this time. Currently, the only physical efforts to control Eurasian watermilfoil have been mechanical harvesting in the Tahoe Keys to clear areas for boat traffic. This method, however, is likely to be one of the contributing factors to its increased spread in Lake Tahoe.

In 2005, the SLC funded and implemented a pilot project in Emerald Bay to examine control methods outside of the Tahoe Keys. The method included diver-assisted hand and suction removal in the infested portions of Emerald Bay. The effort was successful; however, because the work was conducted too early in the season (late May) many plants that were not observed growing early emerged later in the season. Follow-up surveys in the fall found the areas where plants were removed previously were free of Eurasian watermilfoil. Removal activities in Emerald Bay will continue in 2006 and will be expanded to include one of the smaller south shore marinas currently infested.

The Tahoe Resource Conservation District (TRCD) is currently applying for an approximate $500,000 multi-year grant (2007-2010) to survey and remove invasive aquatic weeds throughout Lake Tahoe based on the methodology of the pilot project.

Lessons: The initiative of an agency to take action to combat an invasive weed in a sensitive environment like Lake Tahoe through a pilot removal project has encouraged other key agencies, e.g., TRPA and TRCD, to increase their role in the physical management of invasive aquatic weeds at Lake Tahoe. This has prompted the development of a Memorandum of Understanding, currently in draft, among many federal, state, and local agencies acknowledging the aquatic invasive plant problem at Lake Tahoe and outlining a control and management approach.

For more information and contacts on some of these case studies, see Appendices B-D.

OTHER AIS SPECIES OF CONCERN The following is a representative, rather than comprehensive, list of AIS species not already mentioned in this report. Some are already here in California and widespread, some fairly limited in their distribution, and some are yet to arrive. The list is merely meant to convey some of the variety of challenges and species types that must be addressed by state management programs.

- **African Clawed Frog, *Xenopus laevis:*** Shipped around the globe for use in human pregnancy testing during the 1940s and 1950s, populations of African clawed frogs have been introduced into parts of Europe, North America, and South America. Although its impacts to native fauna have undergone little scrutiny, this voracious and prolific frog has shown a remarkable capacity to colonize a broad range of aquatic habitats. In southern California, it occupies more than a 300-mile long range through seven counties. In 2003, the African clawed frog was found in a pond at Golden Gate Park in San Francisco.
- **Asian Swamp Eel, *Monopterus albus:*** The swamp eel is a fish found in brackish and fresh waters from South America, Africa, and India east to Australia. U.S. populations have been found in Hawaii, Florida and Georgia. It is a voracious predator that poses a threat to native frogs, fish, and aquatic insects. The Asian swamp eel has the ability to live out of water for a considerable length of time, allowing it to move from one body of water to another. The Asian swamp eel was most likely introduced through the Asian food market and/or as an aquarium pet later released.
- **Bullfrog, *Rana catesbeiana:*** The North American bullfrog was introduced to California in the early 1900s. A voracious predator, the bullfrog feeds on snakes, worms, insects, crustaceans, and other frogs and tadpoles. The female can lay as many as 20,000 eggs in a single breeding season. The bullfrog may be having impacts on native frogs, such as the red-legged frog, and has also been implicated as a leptospirosis vector and may pose a threat to human health.
- **Channeled Apple Snail, *Pomacea canaliculata*:** In the United States, this South American apple snail has invaded the southern states of Florida, North Carolina, and Texas, and has moved into central Ohio. It has not yet been found in California in the wild. The apple snail is a common aquarium snail also cultured for sale to restaurants, making its spread through these pathways likely. It has a voracious appetite and will eat most types of vegetation. In Hawaii, the apple snail is considered to be problematic in some natural and agricultural wetlands, most notably in the taro fields which play an important role in Hawaiian culture. The snail's potential as a rice pest as well as a pest of natural wetland ecosystems has spurred the USDA to list them as a high priority threat should they spread or be introduced more widely.
- **English cordgrass, *Spartina anglica*:** English cordgrass is considered the most invasive cordgrass species in the world. It is a hybrid between smooth cordgrass (*S. alterniflora*, native to the eastern United States) and small cordgrass (*S. maritima*, native to Europe and western Africa. New colonies of English cordgrass typically take some time to become established, but once they do, vegetative spread is rapid, smothering natural ecosystems and preventing shorebirds from feeding. In California, it was introduced to the north San Francisco Bay as part of a restoration project in the 1970s, and it has not yet spread significantly from that location. Because of its demonstrated history of invasiveness, this species should be closely watched.
- **Green Sunfish, *Lepomis cyanellus*:** The green sunfish was mistakenly introduced to California from the Midwest in the late 1800s to early 1900s. Green sunfish spawn in shallow waters and have enormous reproductive potential.

They compete with native fishes by feeding on insects and small fish and are adaptable to varying lake conditions and climates.

- **New Zealand Mudsnail, *Potamopyrgus antipodarum:*** Native to freshwater lakes and streams of New Zealand, this snail has spread to six Western states, reaching California's Owens River in the Eastern Sierra in 1999. Since then, it has spread up and down the Owens River as well into seven other sites scattered throughout Northern California. The snail's tight-fitting operculum permits it to survive out of water in damp conditions for several weeks. It likely hitchhiked into California within waders or other equipment used in infested streams. The New Zealand mudsnail has a prodigious reproductive capacity, competes with native mollusks for resources, and offers virtually no nutritional value to aquatic predators. Population levels in California's Putah Creek have been estimated excess of 100,000 snails per square meter (NCSE 1999). To date, limited research has documented decreases in native macroinvertebrate populations in several rivers where the mud snail has invaded.

- **Northern Pacific Seastar, *Asterias amurensis*:** Native to the coasts of northern China, Korea, Russia, and Japan, this five-armed seastar has spread to many other countries. Its arrival has been linked to ballast water discharges. It is a voracious predator, attacking fleshy organisms such as shellfish. Able to detect food from a distance, it dig shallow pits into the seabed to extract prey. The northern pacific seastar was the focus of extensive eradication efforts by the Australian government in the mid-1990s and remains on their watch list because of the threat it poses to shellfish production.

- **Nuclear Worm, *Namalycastis abiuma*:** This 6-foot-long, hot pink worm is native to Vietnam and was first introduced to the waters of Broadkill Beach, Delaware as fishing bait. They are sold for $6.00 to 7.00 each at bait stores, where anglers cut them into pieces. The worms were nicknamed "Nuclear" because of the radioactive symbol on the lid of the package they were sold in. Anglers like them because they do not need refrigeration and they don't bleed or bite like other bloodworms. Not enough information is available to determine how much of a threat these worms may pose.

- **Saltcedar, *Tamarix ramosissima*:** Saltcedar is native to southeastern Europe and much of central Asia and was introduced to the United States as a landscape ornamental and soil stabilizer. In California, it occurs in the southern Klamath Ranges, Central Valley, eastern Sierra Nevada, Tehachapi Mountains, western Transverse Ranges, South Coast deserts to over 6,000 ft in elevation (DiTomaso and Healy 2003), and the southeastern corner of the state. It is now the predominant form of plant life in the riparian forests of the lower Colorado River. Saltcedar is able to colonize small stream channels where it traps sediments and alter the hydrology. True to its name, the tree concentrates salts in its leaves, and when the leaves drop, local soil salinities may increase. Saltcedar's ability to colonize degraded river systems has allowed it to grow in places where cottonwood and other native riparian vegetation may not. Yet its presence also offers cover, shade, and nesting habitat to the endangered southwestern willow flycatcher and other native animal species.
- **Salt-meadow cordgrass, *Spartina patens:*** Salt-meadow cordgrass is native to the upper reaches of salt marshes along the Atlantic seaboard and Gulf Coast of the United States. It has been introduced to British Columbia, California, China, the Mediterranean, Oregon, and Washington. In California, it is found at one site—the marshes of Benicia State Recreation Area. The dense tussocks are steadily spreading in higher marsh habitat, displacing native plant species such as the endangered soft bird's beak (*Cordylanthus mollis* sp. *Mollis*) and pickleweed (*Salicornia* spp.), and reducing the habitat of the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*). The introduction history of this population of *S. patens* is unknown

- **Salvinia, *S. auriculata* complex; *Salvinia auriculata*, *S. biloba*, *S herzogii*, and *S. molesta* :** Native to tropical South America, the Salvinia Complex consists of four closely-related, free-floating aquatic fern species that can be difficult to distinguish from one another. *S. molesta* (Giant salvinia) is considered one of the world's worst aquatic pests; in favorable environments, plants may double in volume within a week. Giant salvinia forms extensive mats that can completely cover water surfaces, overshadowing native plants, reducing available dissolved oxygen, and creating large amounts of decaying plant material. It can also clog water intakes, interfering with irrigation, drainage and electric power generation. Its arrival on U.S. shores has been linked to commercial nurseries and pet stores, where it is sold for ornamental ponds and aquariums. Giant salvinia tends to spread locally because the plants adhere to boats, wheels, and recreational gear entering infested waters. It reproduces so rapidly that infestations quickly become impossible to eradicate. *S.molesta* mats may grow up to 3 feet thick, which hinders the effectiveness of chemical controls. In California, *S. molesta* populations have naturalized in the Colorado River drainage and have invaded some canals in the Sonoran Desert and San Luis Obispo County (DiTomaso and Healy, 2003). It has also been detected in two ponds in San Diego County. An eradication plan is being created for these sites.
- **Snakehead, *Channa micropeltes:*** The snakehead is a fish native to China. It can be found in a variety of habitats, and can breathe air with a bladder that works like a primitive lung and was most likely imported from Asia to the United States as a food fish. It is also sold in the aquarium trade. The snakehead is a voracious predator with no natural enemies. It disrupts native aquatic ecosystems and transmits diseases and parasites, including several species that can infect humans. Their impact on local economies dependent on fishing and other related resources is significant. All 28 species of snakehead are on the federal list of injurious wildlife species, and their importation and transportation across state lines is illegal. See also federal risk assessment at http://fisc.er.usgs.gov/Snakehead_circ_1251/html/risk_assessment_process.html
- **Water lettuce, *Pistia statiotes*:** Water lettuce is a floating aquatic plant native to South America and is considered to be one of the worst weeds in subtropical and tropical regions of the world. Under optimal environmental conditions, water lettuce can double its population size in less than three weeks. Seed production makes this plant resilient to adverse environmental conditions such as drought. Water lettuce populations often form large, impenetrable floating mats, limiting boat traffic, recreation, flood control, and wildlife use. It is a popular species for pond landscaping and is frequently sold through nursery mail order catalogs and on the Internet. In California, it is found in the eastern Sonoran Desert (Colorado River drainage) but its range is expected to expand (DiTomaso and Healy 2003).
- **Yellow Flag Iris, *Iris pseudacorus*:** A hearty perennial that grows from tuberous rhizomes, yellow flag iris can grow to 5 ft tall. It is a European native that has adapted well to conditions throughout the U.S., where it can now be found in at least 40 states. It typically grows in wetlands, along river and stream banks, in irrigation ditches and on the margins of lakes and ponds. It was first found in California in the 1970s. It now occurs in the San Francisco Bay region, southern San Joaquin Valley, Central Coast, and South Coast (DiTomaso and Healy 2003). When consumed in large quantities, yellow flag iris can be toxic to livestock. A resinous substance from the leaves and rhizomes can irritate the skin of those removing the rhizomes by hand. Pulling the rhizomes can cause extensive damage to the substrate, inviting the establishment of other unwanted plants. Control techniques such as burning are not recommended because the rhizomes re-sprout. Cutting followed by herbicide applications may be the best method to control this plant.

VI: Management Actions, Strategies & Objectives

PLAN GOAL: Minimize the harmful ecological, economic, and human health impacts of aquatic invasive species.

To assist in attaining the goal of the California AIS Management Plan, eight major objectives have been identified:

1. **COORDINATION & COLLABORATION:** Improve coordination and collaboration among the people, agencies, and activities involved with AIS.
2. **PREVENTION:** Minimize the introduction and spread of AIS into and throughout the waters of California.
3. **MONITORING & EARLY DETECTION:** Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.
4. **RAPID RESPONSE & ERADICATION:** Establish systems for rapid response and eradication.
5. **LONG-TERM CONTROL & MANAGEMENT:** Control the spread of invasives, and minimize their impacts on native habitats, listed species and restoration projects.
6. **EDUCATION & OUTREACH:** Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.
7. **RESEARCH:** Increase research on AIS, the economic impacts of invasions, and control options to improve management.
8. **POLICY:** Ensure State laws and regulations promote the prevention and control of AIS.

Associated strategies and specific actions pertaining to each of the above objectives are presented in this chapter. These actions have been identified as being key tasks necessary to more effectively manage aquatic invasive species. The proposed objectives, strategies, and actions in this plan should be regularly reviewed, and should provide annual opportunities for updates and adaptation to new knowledge and circumstances.

Plan Development Process

The plan goal, objectives, strategies, and specific actions were developed with input from a series of stakeholder scoping meetings, inter-agency staff communications, and public workshops held in 2002 and 2006 (Appendix F).

Funding & Implementation

Many of the suggested tasks in the following pages will require additional funding sources to be identified and implemented. The tasks presented here are what "should" happen in order to have an effective statewide AIS management program for California. Like many other states across the nation, however, California is currently undergoing budgetary restrictions, and financial support for many of these tasks is uncertain.

Entities

The entities listed in parentheses after each task are meant to represent the suggested key implementation entities. In most cases, this includes those entities that have the responsibility and/or authority to implement the appropriate tasks. The entities are presented here only as a guideline, and as implementation progresses, the implementing entities may change. The implementation table in Chapter VII provides more details on lead entities and cooperating entities. Federal, regional, and local agencies will not be listed as implementing agencies, since this is a state plan. The state agencies will coordinate with federal, regional, and local agencies whenever appropriate.

Year

The year associated with each of the tasks indicates the suggested year in which to begin implementation. For some of these tasks, this may be extremely optimistic, but represent what should happen if California is to properly address its aquatic invasive species problems.

Discussion

Because California has no comprehensive AIS program, many details are included with the following tasks. These “discussion” statements are intended to give the reader a better sense of the task itself, why it is suggested, and/or knowledge of activities already underway relating to the task. It is hoped that after reading information presented in other parts of the plan, in association with the discussion points presented with these tasks, the reader will have a solid understanding of the issues facing California in terms of AIS, and also of the possible solutions.

OBJECTIVE 1: COORDINATION & COLLABORATION

Improve coordination and collaboration among the people, agencies and activities involved with AIS.

AIS management activities are currently spread across multiple state agencies. Managers working on AIS have been coordinating activities on specific AIS issues though a variety of venues and networks, but not on a holistic level due to the lack of a formal coordinating framework for AIS in California. The actions under this objective seek to describe a new coordinating framework. This framework will allow for the comprehensive assessment of AIS activities and ensure action on high priorities. This coordinating framework combines: an executive level consultation process for state agencies involved with AIS management (critical to providing policy level direction, planning and funding); the creation of a California AIS Team (CAAIST) made up of the lead representative for AIS from each state agency and/or department; and the development of technical advisory panels to provide forums for input from federal agencies, local agencies, research institutions, NGOs, Native American organizations, and stakeholders. This coordinating structure is an important component of the state AIS management program.

STRATEGY 1A: INTERNAL STATE COORDINATION

Identify and coordinate all agencies, programs and representatives within the state government involved with AIS.

ACTIONS

1A1. Develop an executive level consultation process for the state agencies involved with AIS management

(All Agencies) Year 1

Discussion: Coordination and consultation at the executive level are critical to provide policy level direction and planning for the State that includes legislation, funding, and program direction for all state departments responsible for addressing invasive species issues. This can be accomplished by regular briefings to agency and department directors by key state AIS managers. The formation of an AIS or Invasive Species Council made up of department and agency upper management would provide a venue for coordination and consultation at the executive level. In the absence of an AIS or Invasive Species Council, coordination could be accomplished through the California Biodiversity Council. In addition, briefing should be made to the Ocean Protection Council.

1A2. Form a California AIS Team (CAAIST) made up of representatives from each state agency involved with AIS, and have the team meet regularly.

(All Agencies) Year 1

Discussion: Each state agency and/or department has identified a lead representative for aquatic invasive species (see management framework in Section IV). This team will meet regularly to coordinate implementation of the state AIS plan. This team will report to executive level managers to implement actions in the plan (Action 1A1). The team will be led by DFG's State Invasive Species Coordinator.

1A3. Form and fund technical advisory panels to work under CAAIST and to address specific issues within the plan.
(CAAIST, Agencies, Research Institutions, NGOs, stakeholders) Year 1
<u>Discussion:</u> Technical advisory panels will need to be convened to address specific issues within the plan. In addition to state agency staff, the panels will be made up of representatives from the following groups: federal agencies, local agencies, research institutions, NGO's, Native American organizations, and stakeholders. Examples of the types of technical advisory panels that will be formed will include, but are not limited to, the following: Plan Implementation, Permitting, Species Management, Rapid Response, Monitoring and Research, Policy, and Vector Management.

1A4. Clarify which state agencies have lead jurisdiction for more specific AIS issues related to particular species, habitats, water bodies or invasion vectors.
(CAAIST, Policy Panel, All Agencies) Year 1
<u>Discussion:</u> A more formal decision-making structure needs to be established to address different agency mandates, integrate the many different programs addressing diverse AIS issues, avoid duplication, and ensure cost-effective use of limited resources. The current structure revolves around piecemeal funding availability rather than efficiency and priority actions.

1A5. Identify personnel needs within each agency. Employ needed personnel, or reassign existing staff, to focus solely on AIS issues and plan implementation (new funding may be necessary).
(All Agencies) Years 1-3
<u>Discussion:</u> Given the large scope and threat of AIS in California, additional staffing is clearly needed. In addition to lead management AIS positions in key agencies, it will be necessary to have new or reassigned invasive species focused positions to complete the actions in the plan including surveying, monitoring, rapid response, education, work with regional and watershed groups, volunteer efforts, and other specific tasks. Though these positions are considered integral to the implementation of this plan, they will not be assigned tasks, or to a lead entity, until funding can be secured.

1A6. Create a database of ongoing AIS projects in California.
(CAAIST, All Agencies) Year 2

1A7. Assess the effectiveness of all AIS programs and projects undertaken by state agencies, and identify and address any gaps in these activities.
(CAAIST, Plan Implementation Panel) Year 2
Discussion: The Implementation Panel will review and assess implementation of the plan after years 1, 2, and 5. The Implementation Panel will make recommendations to CAAIST. The CAAIST will forward the recommendations to the Executive Chiefs, the Biodiversity Council, the Ocean Protection Council, and the AIS or Invasive Species Council (if formed).

1A8. Coordinate state AIS management activities with the State Water Resources Control Board and the Regional Water Quality Control Boards.
(CAAIST, DFG, SWRCB, RWQCBs, DFA, SLC, DBW) Year 1
Discussion: AIS often exacerbate or complicate pollution control and water quality management. State AIS management activities should be coordinated, through the state and regional water quality control boards, with state Watershed and Basin Plans, TMDLs for water bodies on the 303 (d) list, and the National Pollutant Discharge (NPDES) permitting process.

1A9. Develop and annually or biennially update a list of AIS experts in California, including taxonomic experts for AIS identification.
(CAAIST, Monitoring and Research Panel) Year 1
Discussion: The federal ANS Task Force, USGS, and USFWS are currently working on developing a list of experts. State agencies should collaborate with the federal agencies on developing and updating the list and making it available to AIS resource managers.

STRATEGY 1B: LOCAL AND NATIONAL COORDINATION

Continue and improve collaboration among local, regional, state and federal agencies addressing AIS issues, and communication with non-governmental organizations, community groups and business interests affected by AIS management.

1B1. Identify AIS representatives within key regional and federal agencies, and NGOs.
(CAAIST) Year 1
Discussion: This task should be completed in collaboration with regional and federal agencies, and NGOs.

1B2. Identify conflicts and overlaps between state programs and local and federal programs, and between state programs and NGOs, if any.
(CAAIST, Policy Panel) Year 1
Discussion: This task should be completed in collaboration with regional and federal agencies, NGOs, and local watershed management groups.

1B3. Invite community groups (Native American organizations and industry, business, professional and other groups impacted by AIS management efforts) to participate in planning activities, and to learn more about their role in AIS introduction and dispersal.
(CAAIST) Year 1 and Ongoing

1B4. Form partnerships with Mexico, Canada, Oregon, Washington, Nevada, Arizona and Colorado River states and secure their input and assistance with AIS issues affecting the Pacific Coast.
(Governor's office, All Agencies) Ongoing

STRATEGY 1C: TASK FORCES & CONFERENCES

Participate in, and support, appropriate regional, federal, and international efforts addressing AIS.

1C1. Continue and expand participation in regional, national and international efforts and task forces focusing on AIS issues.
(All Agencies) Ongoing
Discussion: Participation should extend to the federal Aquatic Nuisance Species Task Force, the Western Regional Panel, federal ballast water and hull fouling activities, the Pacific Ballast Water Group, the Global Invasive Species Programme, the Invasive Species Advisory Council, the 100th Meridian Project, among others. State departments and agencies need to appoint contact staff to these committees, task forces and programs.

1C2. Continue and expand participation in localized efforts and task forces focusing on AIS issues.
(All agencies) Ongoing
Discussion: Participation should extend to the Southern California *Caulerpa* Action Team, the Lower Colorado River Giant Salvinia Task Force, Team Arundo, the CALFED Bay-Delta Authority Nonnative Invasive Species Program, among others.

1C3. Participate in national and international conferences concerning the management and control of AIS.
(All agencies) Ongoing
Discussion: AIS conferences increase knowledge of efforts and successes elsewhere, as well as ensure awareness of California's issues and activities outside the state. Authorization for key out-of-state and out-of-country travel should be promoted. Funding for attendance and participation of resource managers and scientists in these conferences needs to be identified.

STRATEGY 1D: FUNDING

Increase existing funding sources, and develop new long-term funding, for AIS management.

1D1. Identify and apply for grant funding available in California and nationally.
(All Agencies) Year 1-5
Discussion: The federal Nonindigenous Aquatic Nuisance Prevention and Control Act enables the Governors of States to request federal assistance for up to 75 percent of the cost incurred to implement state aquatic invasive species management plans. Currently, the USFWS has a limited budget for grants for this purpose. California needs to articulate the importance of a significant federal partnership to address the risks of aquatic invasive species.

1D2. Establish stable, long-term funding to assist in the implementation of some of the AIS management activities identified in this plan.
(CAAIST, Policy Team) Year 1-3

The Case for Permanent Funding
Dedicated permanent funding, to support permanent staff and agency programs, will be a key to effectively addressing AIS issues in California. Though many AIS activities are currently underway throughout the State, almost all of these are operating on 'soft' (short-term/grant) money – a very inefficient approach in the long-term because so much time and effort must be spent on soliciting grants rather than on managing invasive species. Such grants also result in high staff turnover (including short-term hiring and rehiring); the necessity of writing various status reports to comply with grant requirements; and gaps in eradication and control efforts between funding opportunities, allowing for the recovery of AIS. Thus while soft monies can be very effective for short-term projects such as research studies, they may compromise long-term program operations. There is a clear need for dedicated permanent funding to address aquatic invasive species issues in California.

OBJECTIVE 2: PREVENTION

Minimize the introduction and spread of AIS into and throughout California waters.

Prevention (as opposed to control efforts once a population is established) is known to be the most cost effective and environmentally sensitive method of managing AIS. The movement of AIS into and within California is not only taking place via transoceanic ships, but also via other vectors such as aquaculture, the aquarium trade, the bait industry, recreational activities, biological research, environmental restoration projects, and even freshwater deliveries up and down the state's pipelines and canals. In the past, efforts to control invasions have focused on managing individual problem species. More recently, however, more efforts and resources are being directed toward managing vectors. For aquatic species in particular, vector-based management may be much more effective than species-based approaches. Current California management will continue to occur on both the species and vector level. The actions suggested below seek to: identify high priority vectors and improve programs aimed at addressing them; strengthen enforcement and inspection at entry points; and sustain and expand the state's current ballast water management program and proposed hull-fouling control program. Prevention is a central focus of this plan.

STRATEGY 2A: VECTORS

***Identify possible vectors and pathways of AIS introductions into and throughout California and assess the risks and impacts of each*.**

ACTIONS

2A1. Create a more comprehensive list of pathways than that presented in this plan.

(Vector Management Panel, CAAIST, OPC) Year 1

Discussion: The known and suspected AIS vectors and pathways into California include ship ballast water, hull fouling, aquarium trade, live seafood industry, aquaculture, research, recreation, and others. A more comprehensive vector assessment is needed in order to identify prevention strategies.

2A2: Using the more comprehensive assessment of current vectors developed in 2A1, conduct a risk analysis to prioritize vectors for management.

(Vector Management Panel, CAAIST, OPC) Year 1

Discussion: All vectors will need to be quantified and assessed to create an effective prevention program. Currently the only comprehensive analysis has been conducted on noxious weeds vectors and ballast water and hull fouling from commercial vessels. On going work should be continued on these vectors. The following vectors have specific actions in this plan, directing agencies to quantify and assess the role of the vector: commercial fishing, recreational boating, recreational fishing, live bait, imported seafood, aquaculture, aquarium and aquascaping (water garden), fisheries enhancement, unauthorized stocking of nonnative species, research and educational activities, shipment of live aquatic species, construction activities restoration activities, and the water delivery and diversion system. The assessments begin in different years depending on current need. This assessment will conduct a more comprehensive analysis, which could result in a reprioritization of activities. In addition, there are other vectors that will need to be assessed including general water-based activities (swimming, diving, etc.), sea planes, and other vectors identified in action 2A1. Higher priority vectors should be quantified and assessed first.

2A3. Identify ecologically sensitive waters as targets of additional precautionary protocols.

(DFG, DFA, DPR) Year 2 and Ongoing

Discussion: To the extent possible, existing designations (e.g. National Estuarine Research Reserves, Marine Reserves, Critical Coastal Areas, etc.), will be used to compile locations and maps of ecologically sensitive waters.

STRATEGY 2B: ENFORCEMENT & INSPECTION

Increase enforcement of vector-based existing regulations controlling the transport, propagation, sale, collection, possession, importation, purchase, cultivation, distribution and introduction of AIS.

2B1. Increase staffing and hours of operation at DFA Agricultural Check Stations.

(DFA, DFG) Year 1

Discussion: The DFA Check Stations are the first line of defense in blocking AIS from traveling overland into California. Inspecting for AIS is an extension of traditional check station responsibilities which should be supported with the provision of additional staff whenever possible.

2B2. Increase DFG staffing to effectively enforce current regulations on prohibited and restricted species, and on movement of aquatic species. This includes monitoring local vendors and facilities to ensure compliance with their permits, as well as monitoring permitted introductions.

(DFG) Year 1

Discussion: Various regulations currently exist to protect valuable resources against the introduction of prohibited and restricted species, including disease agents. Additional personnel could lead to more comprehensive enforcement of these regulations.

2B3. Ensure adequate staffing and clear guidelines for inspectors and enforcement officers at maritime ports and at airports for inspecting cargo.

(DFA, DFG, DHS) Year 3-5

Inspecting cargo is a critical step in preventing unwanted species from entering the state. Adequate staffing and clear guidelines are needed for inspectors to be effective. Close coordination and collaboration with federal inspectors (including USCG, USFWS, USDA), will be required. Training for inspectors should be evaluated and updated as necessary.

2B4. Continue disease sampling for shipments and stocks of live fish and other species, and assess whether current systems are adequate to keep contaminated stocks from being distributed via aquaculture, the aquarium and bait trade, terminal food markets, research activities and government stocking programs.
(DFG) Ongoing

2B5. Develop a program to identify mail order and online vendors who are selling California prohibited and restricted species and work with these vendors to keep AIS from being imported into the state.
(DFA, DFG) Year 2
Discussion: There are multiple cases of restricted and prohibited stocks being sold without detection by government regulators, not only in local venues, but also through mail order or from on-line sources. Any California enforcement should integrate with efforts such as USDA's current development of a WebCrawler designed to identify online vendors of federally listed noxious weeds and regulated plant species.

STRATEGY 2C: COMMERCIAL VESSELS & MARITIME ACTIVITIES VECTOR
Reduce the introduction and transfer of marine AIS via ballast water, ballast sediment, and hull fouling from commercial vessels and maritime structures.

2C1. Quantify the ballast water vector and assess the risk of ballast water as a mechanism for the introduction and dispersal of AIS throughout California.
(SLC) Ongoing
Discussion: In 2000, CLSC began collecting ballast water report forms from all vessels coming into California from outside the EEZ (Exclusive Economic Zone, 200 nautical miles offshore). These reports include information about port of origin, how the ballast water was managed (i.e. open ocean exchange), and how much ballast water was discharged. In 2004, CSLC expanded their program to require ballast water reports from all vessels, regardless of the last port of call. This comprehensive reporting program is essential to help quantify the extent of the ballast water problem, and how it my change over time due to changes in trade routes and/or ballast water management requirements.

2C2. Assess the impacts of hull fouling and ballast water as mechanisms for the introduction and dispersal of AIS throughout California.
(SLC, DFG) Ongoing

2C3. Continue to develop ballast water inspection and enforcement program.

(SLC) Ongoing

Discussion: CSLC should continue current ballast water inspection and enforcement program. Training for inspectors should be evaluated and updated as necessary. In addition, they should continue developing new tools to improve the program, including developing a tool to verify if an open-ocean ballast water exchange has been conducted.

2C4. Adopt performance standards for the discharge of ballast water.

(SLC) Ongoing.

Discussion: In January 2006, the CSLC approved the report titled "California State Lands Commission Report on Performance Standards for Ballast Water Discharges in California Water (Falkner et al., 2006). This report includes interim performance standards, an implementation schedule, final discharge standards and other programmatic recommendations. The report was forwarded to the California Legislature on January 30, 2006 for consideration. In February 2006, Senator Simitian introduced Senate Bill 497, which among other provisions will require the CSLC to adopt, via regulations, the interim standards and implementation schedule outlined in Tables X-1 and X-2 of the report.

2C5. Identify and address gaps in the Marine Invasive Species Program that have not been addressed by either federal or state law.

(SLC, DFG) Ongoing

Discussion: The 2003 Marine Invasive Species Act charged the CSLC with oversight of the state's program to prevent nonindigenous species introductions through commercial shipping. In recognition of the uncertainties surrounding the development of an effective ballast water management program for the State, the Law requires that on or before January 2005 and updated biennially, the CSLC submit to the Legislature and make available to the public, a report that summarizes vessel ballast water activities as they related to the Act and put forward recommendations to improve the State's Program. Likewise, the CDFG is charged with oversight of studies to determine the location and geographic range of NIS in California estuaries and coastal areas and to assess the effectiveness of the ballast water controls implemented pursuant to the Law. CDFG reports their study results to the public annually.

2C6. Coordinate State Ballast Water Management Program with Federal Program

(SLC) Ongoing

Discussion: The CLSC has a cooperative agreement in place with the USCG.

2C7. Quantify the vessel/hull fouling vector on commercial shipping vessels and assess the risk of vessel/hull fouling as a mechanism for the introduction and dispersal of AIS throughout California.
(SLC) Ongoing.
Discussion: In April 2006, the CLSC approved the following report: "Commercial Vessel Fouling in California: Analysis, Evaluation, and Recommendations to Reduce Non-Indigenous Species Release from the Non-Ballast Water Vector (Takata, et al., 2006). This report includes recommendations on how commercial vessel fouling should be managed. The recommendations in this report should be adopted. (See also Chapter III).

2C8. Develop commercial vessel fouling outreach and management program based on results from action 2C7.
(SLC) Year 1

2C9. Investigate the degree to which moving maritime industry structures, such as oil drilling platforms and barges, may contribute to AIS dispersal.
(DFG, SLC) Year 3

2C10. Quantify and assess the role of commercial fishing vessels as AIS vector and identify potential management options.
(DFG) Year1

2C11. Develop commercial fishing outreach and management program based on results from action 2C10.
(DFG) Year 2

STRATEGY 2D: RECREATION VECTOR

Limit new AIS introductions through recreational boating, fishing, diving, and other water-based activities.

2D1. Quantify and assess the role of recreational boating as an AIS vector and identify potential management options. (DFG, DBW) Year1
Discussion: A vector assessment would include the following: Conduct a boater survey in California to determine patterns and frequency of watercraft use, and transport routes between waterways. Link boater survey results to hull fouling studies: amount of fouling, type of antifouling paint, etc.
This study needs to be conducted in for trailered boats and for boat moving in the water.

2D2. Develop a comprehensive recreational boating outreach and management program based on results from action 2D1.
(DBW) Year 2

2D3. Develop comprehensive guidelines for border inspections of boats, boat trailers and water-based equipment entering California.
(DFA, DFG) Year 1

2D4. Develop a watercraft inspection program for high priority boat launch sites.
(DBW, DFG) Year 3

2D5. Develop guidelines for disposal of invasive species removed from marina areas.
(DFG, DBW) Year 2

2D6. Quantify and assess the role of recreational fishing as an AIS vector and identify potential management options. (DFG, DBW) Year 2

2D7. Develop a recreational fishing outreach and management program based on results from action 2D6.
(DFG) Year 3

2D8. Develop and distribute guidelines for cleaning fishing gear and equipment.
(DFG) Ongoing
Discussion: Contaminated recreational fishing gear and waders function as mechanisms for the introduction and dispersal of AIS throughout California. The angling community is particularly interested in curbing the dispersal of AIS. DFG will continue to work closely with these and stakeholders to identify methods to decontaminate equipment.

2D9. Develop and distribute guidelines for disposal of live bait.
(DFG) Year 1

2D10. Link activities in 2D to the national *Stop Aquatic Hitchhikers* campaign. (DFG, DBW) Year 1
Discussion: This campaign, organized by USFW seeks to educate boaters, fishers, divers and others about aquatic hitchhikers and how to prevent them from spreading (ProtectYourWaters.net). See also Appendix D.

STRATEGY 2E: LIVE BAIT, SEAFOOD, AQUACULTURE & AQUARIUM VECTORS
Work with appropriate industry representatives who may be potential pathways to ensure awareness of the threats and prevention of introductions and transfers.

Discussion: The definition of aquarium may include hobby aquarists, public aquaria (such as Monterey Bay Aquarium), and research aquaria (such as Bodega Bay Marine Lab)

2E1. Quantify and assess the role of live bait as an AIS vector and identify potential management options.
(DFG) Year 2

2E2. Work with the live bait industry to develop preventative strategies, identify education needs, and implement permitting of bait imports.
(DFG) Year 2
Discussion: Guidelines need to be developed on the use of packing materials for live bait transport**.** An implementation plan needs to be developed to facilitate permitting bait imports.

2E3. Develop a live bait outreach and management program based on results from actions 2E1 and 2E2.
(DFG) Year 3

2E4. Quantify and assess the role of imported seafood as an AIS vector and identify potential management options.
(DFG) Year 2

2E5. Work with the live seafood industry to develop preventative strategies and identify education needs.
(DFG) Year 2
Discussion: Guidelines need to be developed for use of plants and other live packing materials for seafood transport.

2E6. Develop an imported seafood outreach and management program based on results from actions 2E4 and 2E5.
(DFG) Year 3

2E7. Perform an inventory and associated risk assessment of the discharge, overflow systems, and storm/flood containment systems of aquaculture, public aquariums, and research facilities to determine the potential risks of effluents, and propose remedies for remediation and monitoring requirements.
(SWRCB, DFG) Year 3
Discussion: The level of risk currently posed by these facilities in not known, and must be more accurately assessed. Though containment procedures must be outlined in the permit process of such facilities, follow-up has been inadequate to ensure procedures and systems are in place and effective. Methods already exist to evaluate the risks associated with this pathway such as those presented in the Aquatic Nuisance Species Hazard Analysis Critical Control Point (ANS-HACCP) planning process. USFWS has adopted ANS-HACCP as a national tool for use by federal fish hatcheries and developed guidance materials and training to facilitate its use.

2E8. Work with the aquaculture industry to ensure understanding of the importance of containment systems as well as the threat that escapees may pose to native species and habitats.
(DFG) Year 2
Comment: DFG should provide HACCP training and assist in development of HACCP plans.

2E9. Develop an aquaculture outreach and management program based on results from actions 2E7 and 2E8.
(DFG) Year 4

2E10. Quantify and assess the role of the aquarium and aquascaping (water garden) trade as an AIS vector and identify potential management options.
(DFG) Year 1

2E11. Work with aquarium, water garden, and other target industries to educate consumers, retailers and wholesalers of the importance of preventing the release of unwanted organisms into aquatic systems.
(DFA, DFG, CACASA) Year 1

2E12. Work with aquarium, water garden, and other target industries to ensure that there are easily accessible, appropriate locations and methods for disposal of aquatic organisms.
(DFA, DFG) Year 1

2E13. Implement an aquarium and aquascaping outreach and management program based on results from action 2E10.
(DFG) Year 2

2E14. Link the activities in 2E10-13 to the national *Habitattitude* outreach campaign developed by the Pet Industry Joint Advisory Council, USFWS, and NOAA National Sea Grant College Program.

STRATEGY 2F: *FISHERIES ENHANCEMENT VECTOR*
Assess and minimize activity related to planned, authorized introduction of non-native species into inland water systems.

2F1. Quantify and assess the role of fisheries enhancement as an AIS vector and identify potential management options.
(DFG) Year 1

2F2. Perform an inter-agency review and assessment of DFG's authorized practice of intentional introductions of non-native species into aquatic habitats for recreational purposes.

(DFG) Year 1-2
Discussion: While introductions into artificial systems (lakes, fishing lagoons, etc.) may be relatively harmless, it is appropriate to review current procedures to ensure that AIS don't escape and that DFG is not deliberately introducing potential AIS. An assessment of the current introduction practices into streams is also warranted, as well as the development of a DFG agency protocol on this issue.

2F3. Explore ways to reduce the amount of unauthorized stocking of nonnative species into aquatic habitats.
(DFG) Year 2

2F4. Assess the efficacy of, versus threats from, the authorized introductions of *Poeclilids* into native habitats for mosquito control.
(DFG) Year 1
Discussion: The practice of stocking streams, ditches, and other inland waterways with *Poeclilids* (i.e. mosquitofish) to control mosquitoes should be evaluated. Though mosquito control to address human health concerns is certainly important, *Poeclilids* are known to be harmful to native insect and fish species. Research suggests that the use of *Poecilids* to control mosquitoes is not necessarily an effective mechanism in some cases.

STRATEGY 2G: RESEARCH & EDUCATION VECTOR
Minimize AIS introductions and transfers by researchers and others involved in field activities.

2G1. Quantify and assess the role of research and educational activities as an AIS vector and identify potential management options.
(DFG) Year 2

2G2. Establish and make available protocols to minimize the spread of AIS into the wild from research, monitoring, and control activities, and incorporate this aspect into funding requests.
(DFG, DFA, Universities) Year 3
Discussion: With the rise in AIS work suggested by this plan, there will be a corresponding increase in the chance of transferring AIS during research or management activities. Protocols addressing this task should be a standard component of all field activities that involve AIS or infested waters, as well as a required component of AIS grant proposals. Some protocols already exist such as those presented in the Aquatic Nuisance Species Hazard Analysis Critical Control Point (ANS-HACCP) planning process.

2G3. Evaluate existing, or establish new, regulations and protocols for in-water (non-lab) based research experiments that could potentially introduce or involve the culture or movement of nonnative species into areas where they do not currently exist.
(DFG, Universities) Year 4

Discussion: Outreach is necessary to ensure that researchers understand that these activities are regulated by Private Stocking Permits. In addition, permit evaluation should include scrutiny of potential AIS issues.

2G4. Quantify and assess the role of the shipment of live aquatic species for use in research or educational activities as an AIS vector.
(DFG, Universities) Year 4
Discussion: Marine and freshwater species can be ordered from research and educational supply companies around the work through catalogues or Internet. Once the organisms are delivered, improper handling techniques may result in the release of non-native species.

2G5. Develop a comprehensive research and educational activities outreach and management program based on results from actions 2G1, 2G2, 2G3, and 2G4.
(DFG) Year 5

STRATEGY 2H: CONSTRUCTION AND RESTORATION VECTOR

Limit new introductions of AIS as a result of restoration, landscaping and construction activities

2H1. Quantify and assess the role of construction activities as an AIS vector and identify potential management options.
(DFG) Year 3

2H2. Work with industry and consultants to develop guidelines for decontamination of construction equipment, tools and protective clothing.
(DFG, SLC, DPR, BLM) Year 1-3

2H3. Develop a construction outreach and management program based on results from actions 2H1 AND 2H2.
(DFG, SLC, DPR, BLM) Year 4

2H4. Quantify and assess the role of restoration activities as an AIS vector and identify potential management options.
(DFG) Year 2
Discussion: Construction equipment used for restoration work, as well as soil from nurseries and dredged material used for restoration, can all be vectors for AIS.

2H5. Work with consultants and other groups conducting habitat restoration projects or landscaping projects to encourage the use of native species (with propagules from appropriately local stock) or noninvasive non-native species, and minimize the transfer of AIS.
(DFG, SCC) Year 1-3

Discussion: Non-native species should not be used in habitat restoration and mitigation projects. All approved mitigation and restoration projects should include a program for periodic site monitoring for non-native species and a program for control and, if appropriate and feasible, eradication should an introduction occur. The use of non-native plant species in public access landscape improvements should be avoided where a potential exists for non-native plants to spread into the Bay, other waterways, or transition zones between tidal and upland habitats. Programs and outreach materials should be developed to educate stakeholders (individuals and groups involved in wetland monitoring, restoration and mitigation) about the impacts of species introductions and what they can do to prevent them.

2H6. Develop a restoration outreach and management program based on results from actions 2H4 and 2H5.
(DFG) Year 3

STRATEGY 2I: WATER DELIVERY AND DIVERSION SYSTEM VECTOR

Limit new introductions of AIS as a result of restoration, landscaping and construction activities

2I1. Quantify and assess the role of the water delivery and diversion system as an AIS vector and identify potential management options.
(DWR) Year 1
Discussion: The state's extensive water delivery, export, transfer and development system, which moves water not only from one watershed to another, but also from one end of the state to another, and even across state lines, can be an important vector of AIS. Water deliveries can spread freshwater-adapted AIS within and out of state, and carry species from infested areas to more pristine locales. Intensive manipulation of natural water paths and river flows, and of the aquatic ecosystem in general, makes California particularly vulnerable to AIS. Not only may AIS be more easily transferred via all these diversions, but they may also find it easier to colonize areas where native species are already stressed by the loss of habitat caused by dams, water diversion, altered hydrology, and development.

2I2. Develop an outreach and management program for the water delivery and diversion system based on results from actions 2I1.
(DWR) Year 2

<u>OBJECTIVE 3: EARLY DETECTION & MONITORING</u>

Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.

Early detection of introductions and quick, coordinated responses can eradicate or contain invasive species at much lower cost than long-term control, which may be infeasible or prohibitively expensive. In California, early detection of nonnative species before they become established should be considered a vital component of addressing AIS. The purpose of this section is to acknowledge the importance of continuing current programs, and to identify gaps and areas for improvement. The state's two current major AIS monitoring programs reflect two different historical approaches to management: DFA monitors specific target species listed as noxious, or regulated in some way, in order to undertake early detection or eradication; DFG monitors populations over time, and notes new populations or changes in species abundance. Both types of monitoring will be critical to sound management in the future, as will more coordination at higher management and planning levels as suggested under Objective 1. Coordination on a more technical level will also be important. As such, some of the following actions aim to better link the many different natural resource and AIS monitoring programs conducted by diverse state agencies, and in coastal, inland and ocean waters, to improve AIS detection. Actions also seek to better integrate GIS mapping into AIS management, and to make state databases more compatible with, and responsive to, AIS management needs.

STRATEGY 3A: EARLY DETECTION

Develop a standardized monitoring system focused on early detection for high priority AIS.

ACTIONS

3A1. Assess all current monitoring of the state's coastal marine and inland waters for opportunities to incorporate early detection of AIS.
(Monitoring and Research Panel, CAAIST, OSA, CeNCOOS, SCCOOS) Year 1
<u>Discussion</u>: High priority AIS for early detection include the zebra mussel, Northern Pacific seastar, snakehead, *Caulerpa,* hydrilla, salvinia, and others.

3A2. Assess how current monitoring under the state's Ballast Water Program could assist with early detection.
(DFG & SLC) Ongoing

3A3. Develop a statewide integrated approach to early detection, based on the assessment in 3A1&2 above. The approach should address any gaps and link directly with the centralized reporting system and rapid response program described in 4A2.
(Monitoring and Research Panel, CAAIST) Year 3

3A4. Conduct outreach to those regularly sampling coastal, marine and inland waters for other purposes, so they can easily identify and report high priority AIS.
(DFG, DFA, DWR, DBW, SCC) Year 1 -3
Discussion: Those already conducting field work or surveys – researchers, graduate students, resource managers, water quality monitors, law enforcement personnel and others – should be encouraged and trained to identify key AIS. State agencies and other organizations should assess where it is possible to add staff dedicated to AIS work, or broaden the scope of work of existing staff to build AIS detection and monitoring into existing workplans. Special identification materials for high priority AIS should be developed and distributed to support the early detection effort.

3A5. Create and train a statewide citizen monitoring network to assist in the detection and monitoring of AIS distribution.
(DFG) Year 3
Discussion: Trained volunteers and knowledgeable water users already working near or in the water (divers etc.) can provide relevant information on the occurrence of new species. To be effective, this network will need to clearly link into an early warning system that incorporates follow-up. Some elements necessary to the development of an effective citizen-monitoring network may include: a structured training program; expansion of current monitoring and restoration programs to better engage community groups; outreach to existing watershed councils, professional diver associations, flood control districts, reclamation districts and other monitoring efforts; distribution of key species pictures and descriptions; and the creation of a website to allow volunteers and water users to report their AIS sightings (see 4A2).

3A6. Regularly review the efficacy of the State's AIS detection and monitoring systems, and pursue any necessary improvements.
(Monitoring and Research Panel, CAAIST, OPC) Ongoing
Discussion: State AIS staff should review the type, intensity, frequency and distribution of monitoring activities on a regular basis to assess continued relevance and effectiveness.

STRATEGY 3B: LONG-TERM MONITORING
Improve and standardize the long term monitoring program for AIS.

3B1. Assess current long-term AIS monitoring efforts for the state's coastal marine and inland waters, identify gaps, and recommend improvements for a more integrated approach.
(Monitoring and Research Panel, CAAIST, OSA, CeNCOOS, SCCOOS) Year 1-3
Discussion: Within the current agency management framework, monitoring occurs, and will continue to occur, on two parallel tracks: DFA monitors

specific target species listed as noxious, or regulated in some way, in order to undertake early detection or eradication; DFG monitors populations over time, and notes new populations or changes in species abundance. Both types of monitoring will be critical to sound management.

3B2. Identify and monitor locations with a high invasion rate.
(Monitoring and Research Panel, CAAIST) Ongoing
Discussion: High risk locations may include ports, ballast water release sites, popular recreational lakes and marinas near state borders, as well as areas with high density AIS populations.

3B3. Identify and monitor the population growth and dispersal of established AIS.
(DFG) Ongoing
Discussion: Species-specific monitoring in particular should occur for those species identified as high risk or high priority. Examples of such species, and those of more established populations of concern which may require monitoring, appear in Chapter IV, Figure 5.

3B4. Obtain funding to incorporate DFG's historical stream surveys, and its report findings, into a central database.
(DFG) Year 1

3B5. Prepare maps of existing AIS in California's coastal and inland waters.
(DFG, DFA, SLC) Year 1-5
Discussion: Mapping is an important step in determining the spatial distribution of AIS, and could help with the completion of other early detection and monitoring tasks. Some maps are available however there is a need for centralized, user-friendly, Internet-based maps.

3B6. Regularly review the efficacy of the State's AIS long-term detection and monitoring systems, and pursue any necessary improvements.
(Monitoring and Research Panel, CAAIST) Ongoing

3B7. Coordinate with Ocean Observing Groups
(DFG, SCC, SCCOOS, CeNCOOS, OSA) Ongoing
Discussion: Monitoring of invasives in the marine and coastal areas of California should be coordinated with the regional ocean observing systems (SCCOOS-Southern California Coastal Ocean Observing System and CeNCOOS-Central and Northern California Coastal Ocean Observing System). Other biological monitoring programs occurring in coordination with these regional systems may be able to provide additional information on identifying new invasions and the distributions and effects of invasive species. The Ocean Science Applications (OSA) program at the SCC, which was recently established by the Ocean Protection Council, may also be able to provide assistance in coordinating with other biological

monitoring progams and making the information accessible to the public and resource managers.

OBJECTIVE 4: RAPID RESPONSE & ERADICATION

Establish systems for rapid response and eradication.

Once AIS are established complete eradication is unlikely to be feasible. Eradication of pioneering populations is feasible, making rapid response a key AIS management task. Once a new invasive species, or a new population of known invasive species, has been surveyed or identified, management should focus on containing its spread and eradicating pioneering populations. This objective outlines important actions necessary for rapid response, which include advance planning, centralized decision-making and reporting systems, and outreach and education of all those who may become involved in sightings, verification and response. It also emphasizes the need for strong links between rapid response systems and the monitoring activities described under Objective 3. And lastly it suggests ways to prioritize eradication programs across the state. In support of these actions and this AIS management plan, DFG has developed a draft statewide rapid response plan (see Appendix A).

STRATEGY 4A: RAPID RESPONSE

Implement a coordinated system for rapid response efforts to contain newly detected AIS.

ACTIONS

4A1. Develop a Statewide Rapid Response Plan.

(DFG) Year 1

Discussion: The California Rapid Response Plan for Aquatic Invasive Species (in draft form as of fall 2006) appears in Appendix A. While the final state rapid response plan is being developed, a general interim emergency response plan should be put in place. New guidelines for local and state rapid response coordination with federal agencies were published in 2005 by the USEPA (see Appendix B, USEPA).

4A2. Develop a formal, centralized system for AIS reports of sightings, verification, and response, in support of 4A1 and Objectives 2 and 3.

(CAAIST, DFG, DFA) Year 1

Discussion: This system would likely be in the form of a website and/or a toll free AIS HOTLINE. It could be modeled on existing hotlines for other environmental or public health threats. Outreach and training related to early detection and rapid response should include instruction in how to use this system.

4A3. Clarify among the agencies and organizations involved, and within the new rapid response process, who is responsible for which areas and/or species, and what these responsibilities entail.

(Rapid Response Panel, CAAIST) Year 1

Discussion: A clear chain of command is needed for a successful rapid response. It is also necessary to identify all federal, regional, state, county, and non-governmental resources that can be mobilized to assist to limit any high-risk introductions.

4A4. Develop species- and/or location-specific rapid response plans.
(DFG, DFA) Years 2-3
Discussion: These plans should include lead agencies, chain of command, specified lists of appropriate control measures (biological, chemical, and physical), methods to address the introduction pathways, and regular updates and drills to ensure the contingency plans remain current.

4A5. Explore the establishment and administration of permanent funding to implement rapid response plans.
(CAAIST, Policy Panel, DFG, DFA, SCC, OPC) Year 2
Discussion: Washington, Massachusetts and other states have established emergency funds reserved for the containment/eradication of pioneering AIS infestations. California needs this kind of emergency funding for immediate control actions. Without such funding rapid response either may not occur, or funds may be unexpectedly re-directed from other important programs. The Ocean Protection Council's Strategic Plan identifies establishment of such a fund for coastal AIS as a high priority.

4A6. Explore the feasibility of preparing emergency contracts with approved private businesses for some monitoring and rapid response work.
(DFG, DFA) Year 3
Discussion: This approach has been used successfully for the eradication and continued surveillance for *Caulerpa taxifolia* (see Chapter V, Case Study).

STRATEGY 4B: ERADICATION

Eradicate targeted populations of AIS.

4B1. Continue and complete current eradication efforts, and conduct follow-up monitoring to ensure eradication.
(DFA, DFG, SCC)
Discussion: As of spring 2006, recent or ongoing eradication programs within the state of California included, but were not limited to, *Caulerpa*, hydrilla, giant salvinia, *Spartina* (Atlantic cordgrass), *Arundo donax*, alligatorweed, Japanese eelgrass, Wakame, and Northern pike. More information on some of these eradication efforts and species appears in Chapter IV & V.

4B2. Review and evaluate eradication programs.
(Species Management Panel, CAAIST) Year 1

4B3. Develop an objective, testable risk-assessment strategy that the committee can use to identify priority species for eradication.

(Species Management Panel, CAAIST) Year 1
Discussion: The new strategy should be based on ecology, biology, economics and other parameters. It should provide a tool for DFA and DFG to reconcile their now inconsistent screening strategies concerning AIS importation, among other uses. It also will divide the species into the different management categories.

4B4. Develop and implement a method to identify priority sites of AIS invasion concern.
(CAAIST) Year 3

OBJECTIVE 5: LONG-TERM CONTROL & MANAGEMENT

Control the spread of invasives, and minimize their impacts on native habitats, listed species and restoration activities.

Very few cases exist worldwide of complete eradication of established populations of aquatic invasive species. A more realistic approach for most established populations is to use control measures to maintain existing AIS populations at an acceptable level. Long-term control and management activities should be focused on populations of established species where there is a clear and significant impact on economically important species, sensitive native species, human health and infrastructure, or recreation and navigation, and where the control of specific populations is feasible both economically and technically. In many cases, control efforts occur as the result of a local management priority – a weed clogging a favorite local fishing spot, swimming hole or creek habitat, for example -- and are undertaken by local groups and entities, sometimes with state support. State control programs tend to focus on larger scale impacts (water hyacinth in Delta waterways, for example), or AIS that threaten sensitive species or protected areas or water conveyance systems. As such, some control programs are coordinated among state, regional and local agencies, and some are not. The actions in this objective seek to prioritize control efforts; coordinate state control efforts with local and federal efforts; provide technical assistance to local watershed groups, irrigation districts and others undertaking AIS management; and address AIS concerns in habitat restoration planning, landscape construction and maintenance projects.

STRATEGY 5A: CONTROL

Control known AIS populations where economically and technically feasible.

5A1. Prioritize control efforts for all organisms, including new organisms of concern.

(Species Management Panel, CAAIST) Year 1

Discussion: With limited resources, prioritization of control efforts will be a necessary part of addressing AIS issues throughout California. Statewide staff must coordinate priorities with local and regional staff and other agencies. A decision tree should be developed for determining whether to implement a control program, what types of control actions to use, and how to accomplish the necessary permitting. Species should be placed in the species management categories mentioned in Chapter IV, Figure 5. Prioritization of control programs may benefit from higher-level discussions and priority-setting concerning the trade-offs among different public interest mandates inherent in AIS management activities.

5A2. Continue ongoing control programs, following program review.

(Species Management Panel, CAAIST) Ongoing

Discussion: Agencies can request that the panel review an ongoing program and provide advice on what future actions should be.

5A3: Develop a method or criteria to prioritize control actions based on both the threat level and the anticipated efficacy of control actions.
(Species Management Panel, CAAIST) Year 1

5A4. Develop new species- and site-specific control plans as necessary based on 4B1-4 above, and on lessons learned from relevant projects inside and outside California.
(DFG, DFA, DBW) Year 2

5A5. Provide technical assistance to watershed councils, irrigation districts and other local boards for development of AIS management plans.
(DFA, DFG) Year 3-5

5A6. Coordinate with federal and regional efforts for managing AIS, as described under Objective 1.
(CAAIST) Ongoing

STRATEGY 5B: LIMIT DISPERSAL TO NEW AREAS

Limit the dispersal of established AIS to new water bodies or to new areas within inland water bodies.

5B1. Establish boat washing stations and disposal facilities at infested water bodies.
(DFG, DBW, DFA) Year 3

5B2. Install warning and information signs in infested areas at local kiosks, boat ramps, and on floating buoys to limit the spread of existing AIS by boats, personal watercraft, movement of live fish and bait buckets.
(DBW, DFG) Year 2

5B3. Use volunteer monitors to conduct AIS inspections at heavily used boat access areas.
(DFG) Year 2

5B4. Develop criteria and a plan for enforcing the temporary or long-term closure of specific areas infested with high priority AIS.
(DFA, DFG, DBW) Year 3

5B5: Support other "limiting the spread" actions as described under Objective 2: Prevention.
(DFA, DFG, DBW) Year 3

STRATEGY 5C: PROTECT NATIVES

Protect areas of special ecological significance, and state and federally listed rare, threatened and endangered species, from AIS invasions.

5C1. Coordinate with appropriate state and federal agencies to identify priority areas.
(DFG, DPR) Years 3-5

5C2. Coordinate with private and local government land management organizations such as conservation groups, mitigation banks, land trusts, and open space districts to meet protection and restoration objectives.
(DFG, TNC) Years 3-5

5C3. Develop GIS-based maps that show coincidence of AIS and critical ecosystems.
(DFG, DFA) Years 3-5

5C4. Establish clear guidelines for action when AIS eradication or control efforts will take place in areas of special ecological significance.
(DFG) Year 2

5C5: Coordinate with outreach programs under Objective 6 to ensure that these guidelines are well-distributed to land managers.
(DFG, DFA) Year
Discussion: Land managers should be informed that if, by following these guidelines, they address issues regarding areas of special significance it may expedite environmental review and permitting.

STRATEGY 5D: RESTORATION & LANDSCAPING

Address AIS concerns in habitat restoration planning, landscape construction and maintenance projects.

5D1. Develop and distribute guidelines for riparian, wetland and shallow water habitat restoration projects to prevent invasions.
(DFG) Year 2
Discussion: Newly cleared and created habitats can easily and immediately be colonized by opportunistic invasives. Preventive measures may be necessary to prevent such invasions and promote native plant and habitat growth. These measures include, but are not limited to, covering the soil, seeding, planting and spraying, and the care and cleaning of construction equipment, tools and protective clothing used in restoration and landscape work.

5D2. Promote the use of native plants and/or non-invasive non-native species in restoration, shoreline landscaping, and for timber,

agricultural, or livestock activities around waterways, as in 5A9.
(DFG, DFA) Year 1
Discussion: Native plants should be derived from appropriately local stock. Guidelines or official policy should be developed for all uses around waterways.

5D3: Develop boilerplate AIS prevention language for agency comments on project plans and other activities.
(CAAIST) Year 2
Discussion: Boilerplate language addressing the need to prevent AIS introduction, or control AIS spread, should be available to agencies commenting on environmental documents, landscape plans, restoration plans and research proposals. Such language should be distributed to all appropriate state, federal and local agency staff.

OBJECTIVE 6: EDUCATION & OUTREACH

Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.

Most people do not recognize the threat that aquatic invasive species pose and how their own actions may lead to new infestations. People have inadvertently introduced invasive species by dumping their unwanted aquarium or bait bucket contents, launching their AIS-contaminated boat, or stocking their private pond. The improper importation and holding of organisms have allowed species to escape, or caused unwanted organisms to become mixed in with intentionally imported ones. Many policy makers, natural resource administrators, and private interest groups have facilitated the intentional introductions of species for economic or recreational purposes, without understanding the effects these species would have on native communities. These intentional and unintentional introductions can be eliminated or curtailed by educating people about the role they potentially play in transferring aquatic invasive species into and throughout California. The desired result of many outreach efforts is to create and sustain social behavior changes in individuals and/or user groups. For many of these strategies and associated tasks, similar efforts are being undertaken in other states, nationally, or internationally. It is emphasized that California should link with these existing efforts, and use, and adapt relevant tools and methods that have proven to be effective elsewhere.

STRATEGY 6A: OUTREACH

Increase education of, and outreach to, those who may be potential sources for AIS introductions.

ACTIONS

6A1. Inventory and assess the effectiveness of existing education and outreach efforts in order to prioritize future strategies, and develop a statewide AIS communication strategy.

(CAAIST) Year 1

Discussion: With limited resources, a dedicated effort is needed to assess the value of education and outreach programs and measure whether they've been effective at changing attitudes, behaviors, and support for AIS management. Any such effort should be closely coordinated with activities under Objective 2: Prevention.

6A2. Partner with national campaigns already involved in outreach.

(DFG, DFA, DBW, SLC, DWR) Year 1

Discussion: National campaigns now well underway are the Habitattitude (pet industry and pet owner outreach) and Stop Aquatic Hitchhikers (boating and recreational outreach). Partners may include NGO programs. See Appendix D.

6A3. Develop and distribute printed material (posters, brochures and articles) for specific industry sectors and user groups.
(DFG, DFA, SLC, DBW, DWR, SCC) Year 2-5
Discussion: Target audiences may include the owners and employees of pet and aquarium stores, and nurseries; wholesalers and shippers dealing in aquarium organisms; operators of water-based businesses (such as boat charter operators, marinas, angling guides, fishing tournament organizers, habormasters, dive shops, seaplane operators, dredging contractors); and university researchers.

6A4. Develop permanent interpretive displays at appropriate marinas, boat ramps, and State fishing access sites.
(DFG, DFA, DBW) Year 2-5

6A5. Work directly with promoters of industry trade shows to deliver the AIS message. (DFG, DFA, DBW, SLC) Year 1-5

6A6. Present and distribute AIS information at various conferences, tournaments, fairs, and other public gatherings.
(All relevant agencies) Ongoing

6A7. Continue to include information on AIS in State hunting, fishing and boating regulations and licenses.
(DFG, DBW) Ongoing

6A8. Publish information about AIS in local fishing and recreational newspapers and magazines.
(DFG, DBW) Year 2-5

6A9. Develop AIS identification cards to be distributed to all appropriate audiences.
(DFG, DFA, CSG) Ongoing

6A10. Encourage industries to offer native alternatives to AIS whenever possible and to educate their consumers about the availability of native alternatives. (DFG, DFA) Year 3-5
Discussion: To aid with this effort, develop “California-friendly” or “green species” lists for specific user groups and industries.

6A11. Partner with diverse stakeholders and interest groups to multiply education efforts and distribute some of the materials developed in 6A2 and 6A8.
(All agencies) ongoing

6A12. Educate waterfront and shoreline property owners, including those on lakes, rivers and streams, about AIS.
(DBW, SCC) Year 3-5

6A13. Develop and offer AIS management classes for professional organizations.
(DFA, DFG, DWR) Year 4
Discussion: Training programs are needed for professionals such as pest applicators, diving instructors, water/irrigation engineers, and habitat restoration planners. Pest applicators and advisors could get AIS management or prevention credits as part of their licensing process.

6A14. Continue state education measures concerning ballast water.
(SLC, SeaGrant) Ongoing

STRATEGY 6B: POLICYMAKERS
Engage policymakers and legislative staff in AIS policy and outreach efforts.

6B1. Identify sponsors in the California legislature and county governments who will support policy issues regarding AIS.
(Policy Panel, CAAIST) Year 1

6B2. Provide decision-makers and legislators with educational briefings on AIS threats and economic impacts, field trips showcasing impacts and controls, and regular updates on AIS management progress.
(CAAIST) Years 1-3

6B3. Periodically update the Fish and Game Commission, SLC, OPC, SCC and CCC on invasive species activities.
(DFG) Year 1-5

STRATEGY 6C: RESOURCE MANAGERS & RESEARCHERS
Increase AIS awareness, and support for management, within the scientific community and natural resource agency staff.

6C1. Increase awareness of AIS among the various scientific and natural resource management interests.
(All Agencies) Year 1-5
Discussion: This effort should promote greater awareness and information-sharing among those working in the field and in resource management projects that may be impacted by AIS. Possible avenues for this networking include: supporting symposia, workshops and conferences (highlighting new findings and activities discussed at local, national and international conferences); developing a centralized AIS communication forum for California (such as a species-specific list serve); and engaging managers and scientists in identifying, monitoring and reporting AIS as described in 3A4. Classes in AIS management (such as those offered by UC IPM) should be offered through public agency training programs, and held in

locations resource managers can easily attend, or be offered on-line or through videos.

6C2. Work with educational institutions conducting scientific research to ensure awareness of proper AIS containment and disposal methods, as well as legal restrictions.
(DFA, DFG) Year 2

6C3. Develop an AIS regulatory handbook.
(Policy Panel, CAAIST) Year 3
Discussion: The handbook should explain laws, regulations and permitting processes aimed at people that will plan or practice various AIS control measures.

6C4. Share and disseminate information on current mechanical, chemical, biological, and physical control methods.
(DFA, DFG, DBW, SLC) Ongoing

STRATEGY 6D: COMMUNITY GROUPS

Develop an education and training program for community groups whose interests relate to AIS so they can assist with early detection and monitoring.

Discussion: Local awareness is a key line of defense against establishment by invasive species. The following strategies can be tied together into a citizen's monitoring network for early detection, as described in 3A5.

6D1. Develop educational tools for the identification of AIS for volunteer groups.
(DFG) Year 2

6D2. Hold workshops geared toward community groups.
(DFG) Year 3

6D3. Integrate AIS monitoring, prevention and control activities into local community service and educational programs (see also 5E).
(DFG) Year 4

6D4. Explore other ways to reach groups with related interests and to tie AIS into their programs.
(DFG) Year 3

6D5. Explore AIS education and involvement opportunities with communities on tribal lands.
(all agencies where appropriate) Year 2-5

STRATEGY 6E: SCHOOLS

Increase AIS awareness within the educational system.

6E1. Train speakers to give guest presentations on AIS issues at schools, and develop resource packets them to use when visiting classrooms.
(DFG, Department of Education) Year 2-5

6E2. Assess existing K-12 environmental education curricula for opportunities to integrate AIS information, and develop new curricula as necessary.
(DFG, Department of Education) Year 3-5
Discussion: AIS related curricula should be integrated into in-service training and continuing education programs for teachers.

6E3. Further integrate AIS issues into service and education projects that involve students as part of a science class, science club, or for community service credit offered at some schools.
(DFG, Various coordinators at site-specific locations) Year 3-5

6E4. Educate teachers about proper disposal methods for organisms used in the classroom and at science fairs to prevent release or transfer of AIS.
(DFG, Department of Education) Year 2
Discussion: ANSTF protocols for science fairs can be adapted to in-classroom disposals and other education activities.

STRATEGY 6F: GENERAL PUBLIC

Raise awareness, concern, and ultimately buy-in on AIS issues for all California residents and visitors.

6F1. Develop a press kit for specific AIS and work closely with the media to ensure the accuracy of any information they publish.
(DFA, DFG) Year 2

6F2. Increase local television, radio and newspaper media coverage of California's AIS threats and management priorities, using the press kit described in 5F2 and other outreach techniques.
(DFG, other agencies) Year1

6F3. Identify key state publications and websites to which AIS information can be added. (All Agencies) Ongoing
Discussion: Ensure appropriate website links are established so that public information on AIS is easy to find and gets good exposure.

6F4. Develop multi-cultural educational materials on AIS that can engage California's diverse population.

(All Agencies) Year 2-5

6F5. Develop a variety of presentations, including AIS traveling trunks and portable presentation boards, for use in both public and private venues.
(DFG, DFA, other agencies) Year 1

6F6: Train individuals to deliver the presentations created in 6F4.

6F7. Create and distribute displays to public venues to improve public awareness of AIS.
(DFG, DPR) Year 2
<u>Discussion:</u> Venues might include State parks, schools, libraries, natural history museums, aquariums, coastal access points and other recreational facilities.

OBJECTIVE 7: RESEARCH

Increase research on AIS, the economic impacts of invasions, and control options to improve management.

Increased knowledge of the biology and ecology of invasive species and associated control methods will allow for the most effective management of AIS in California. Partnerships with universities, research institutes and consulting firms is needed so that agencies can develop their management programs with scientific input. Research is needed to quantify and clarify the effects that non-native species are having on native plants and animals and their habitats. It is also important to know what economic effects AIS are having and whether there are any human health and safety concerns resulting from an infestation. Research is also needed into improved methods of restoring invaded habitats to their native condition, during and after the effective management of AIS. The actions under this objective address these needs.

STRATEGY 7A: BASELINE BIOLOGY

Increase our knowledge about AIS in order to develop effective prevention, control and management programs.

Discussion: Management must be based on solid information on AIS population dynamics, reproductive biology, and ecological conditions fostering growth. Many of these factors are not yet fully understood for the AIS in California.

ACTIONS

7A1. Continue and complete current AIS studies in California.
(All involved in research) Ongoing

7A2. Host workshops to develop AIS research priorities and identify research gaps.
(Monitoring and Research Panel, CAAIST) Year 3
Discussion: In 2005, two research priority workshops were held, one that addressed freshwater invasive plants and another that looked at invasive seaweed research needs. Future workshops could be held in conjunction with the biennial symposia recommended in 6C1.

7A3. Develop a strategy to communicate research needs to the scientific community and research supporters.
(Research Panel, DFG, DFA) Year 3

STRATEGY 7B: ECONOMICS

Increase knowledge of economic impacts of AIS.

7B1. Perform economic impact studies on the effects of AIS to California, including costs and benefits of pathway prevention.
(DWR, DBW, DFA, DFG) Years 2-5

Discussion: A small number of studies around the world have begun to document the economic impacts of AIS, but additional and California-specific studies are needed. In many cases, economic impacts will be the driving force for change in personal and business actions, management, and policy. Prevention is often more cost-effective than control when addressing AIS concerns. Economic analysis can help determine priorities for use of limited funds.

7B2. Determine the economic costs and benefits of pathway prevention.
(DFA, DFG) Year 3
Discussion: Prevention is often more cost-effective than control when addressing AIS concerns. Economic analysis can help determine priorities for use of limited funds.

STRATEGY 7C: MANAGEMENT OPTIONS

Research current and potential management alternatives and determine their efficacy in controlling invasions and their effects on native species.

7C1. Evaluate and research current AIS management methods to improve their efficacy, safety and efficiency.
(Monitoring and Research Panel, CAAIST) Ongoing
Discussion: This should include a comprehensive review of public health and environmental risks associated with various management options so that decisionmakers can take those constraints into account and be better prepared to answer inquiries about any risks. Such a review should occur on a regular basis to identify information gaps and update management options based on new research.

7C2. Investigate the relationship between human disturbance of aquatic and riparian systems and AIS invasion, establishment and impacts.
(DFA, DFG) Year 3-5

7C3. Investigate the efficacy of invasion prevention techniques.
(Monitoring and Research Panel, CAAIST) Year 2

7C4. Support the establishment of a testing and evaluation center for shipboard ballast water treatment technology.
(CSLC) Year 1 and Ongoing
Discussion: In January 2006, the CSLC approved the report titled "California State Lands Commission Report on Performance Standards for Ballast Water Discharges in California Water (Falkner et al., 2006). This report included a recommendation for the establishment of a testing and evaluation center for ballast water treatment technology. The adoption of performance standards for the discharge of ballast waters into California waters must take into account the certification, and subsequent verification of treatment technologies. The existing State program does not have the expertise, equipment, facilities, or financial resources necessary for the

testing and certification of treatment technologies. This infrastructure would substantially improve the effective implementation of performance standards and the ongoing evaluation of technologies once approved. The USCG has recently established a testing and evaluation center in Key West, Florida. However, this single facility will only be able to consider three or four systems annually, once testing and verification protocols are established. Discussions between SLC staff and USCG have identified the need for additional testing and evaluation centers. The SLC staff has proposed the establishment of a center in the San Francisco Bay area that would compliment the USCG's Florida facility. A San Francisco-based facility could offer a testing scenario under rigorous conditions that are widely different from those of Key West. Complementary California and Key West facilities could subject technologies to an array of environmental conditions that may be more reflective of the range of conditions vessels encounter during the course of international trade. The budget to establish such a facility, including capitol start-up cost, personnel, operating expenses and equipment is estimated at approximately $10 million over three years.

STRATEGY 7D: INFORMATION FLOW

Facilitate the collection and dispersal of information, research, and data on AIS in California

7D1. Improve state websites to make information, research and data on AIS more accessible.
(Monitoring and Research Panel, CAAIST, OSA) Year 1
Discussion: There is a need to make easily accessible the information, research and data that will be developed through implementation of this AIS plan. It is critical that state websites are improved in order to facilitate information flow and access to the latest technology and information on prevention, early detection and rapid response, long-term control and management, education and outreach, research and policy.

7D2. Establish opportunities for interagency funding of research necessary for improved management.
(All Agencies) Year 3
Discussion: Consider developing a grant program administered by managers that pools money on a biannual basis to do directed research RFPs.

OBJECTIVE 8: POLICY

Ensure State regulations and policies promote the prevention and control of AIS.

Currently, California has numerous regulations and policies that pertain to the introduction, distribution, importation, transportation, possession, propagation, planting, sale and release of non-native plants and animals. These authorities are spread over several agencies and have been developed over time in response to individual target species and their associated concerns. As a consequence, there is no comprehensive and coordinated program in place to deal with AIS and their associated impacts on a statewide basis. This objective aims to review regulations for gaps and overlaps, identify opportunities for improved regulatory coordination, explore the need for new AIS regulations or policies, and develop secure funding for state AIS management programs.

STRATEGY 8A: REGULATORY REVIEW

Review the laws and regulations governing AIS in California for gaps and overlaps, compare them to other State and Federal AIS laws, and recommend changes to improve our ability to protect California's waters from the introduction and spread of AIS.

ACTIONS

8A1. Establish a regulatory review committee (Policy Panel).
(DFG, DFA, DBW, SLC) Year 1
Discussion: This committee, to be comprised of representatives lead agencies and non-governmental organizations, among others, will emphasize working in a coordinated fashion with existing State, federal, and international programs. The committee will invite input from all groups affected by any proposed pathway control measures, and undertake step 8A2.

8A2. Identify the potential for improved regulatory coordination between State agencies.
(Policy Panel, CAAIST) Year 2
Discussion: The regulatory review committee will also coordinate this effort with tasks under Objective 1.

8A3. Provide the DFG and the DFA with the authority to establish an Aquatic Invasive Species Rapid Response Program, as detailed in Strategy 4A. (DFG, DFA) Year 1

8A4. Explore the need for other new legislation and administrative rules to address gaps in the State's authority to manage AIS, and to strengthen California's AIS-related statutes.
(Policy Panel, CAAIST), Year 1

8A5. Perform an interagency review to assess the current system for regulating plant and animal importations, and the necessity of further restrictions.

(Policy Panel, DFA, DFG) Year 1 and Ongoing

Discussion: Once a nonnative species has been introduced and becomes established, there may still be a need for restrictions on further imports and introductions. This is because when a nonnative species is introduced, it brings with it only a subset of genetic variations of the species itself (host). It may also bring a subset of associated disease agents. If additional specimens of that same host are introduced at a later date, they may subsequently introduce new genetic strains, increase the diversity of the population, and introduce new parasites or disease agents that may harm native species.

STRATEGY 8B: FUNDING

Obtain dedicated long-term funding from the California State Legislature to implement AIS Management Plan tasks and provide matching funds for Federal grants.

8B1. Provide State funding for the AIS positions as detailed in task 1A5.

Year 1

8B2. Provide State funding to the DFG for the creation of an Aquatic Invasive Species Rapid Response Program as described in Strategy 4A.

Year 2

8B3. Provide funding to hire a funding development specialist.

Year 1

Discussion: Hiring a specialist for 2-3 years to explore and develop funding sources would free up the AIS coordinator to focus on establishing the program necessary to carry out the plan.

8B4. Provide a mechanism to obtain funding to implement additional tasks referred to in this AIS Management Plan, which include education, control, monitoring, and research.

Years 2-5

Discussion: This mechanism could draw on user fees, visitor taxes, general funds, etc., and build on participation from industries that contribute to and/or are impacted by AIS.

VIII. PRIORITIES, IMPLEMENTATION TABLE & PLAN EVALUATION

Priorities

A short list of high priority actions will be compiled in this section for the final document. This portion will not be completed until we obtain comments on the August 2006 draft plan.

Plan Evaluation

To evaluate the effectiveness of the plan, formal evaluation will be conducted on a regular basis. Systematic monitoring and evaluation of the progress made toward implementation of actions and their effectiveness will be undertaken by the agencies designated as leads on the implementation table. Updates will be compiled by DFG on an annual basis.

In addition to an evaluation of efforts and implementation, the objectives, strategies, and actions will also come under regular review, as this plan is intended to adapt to changing circumstances. This evaluation will be conducted the Plan Implementation Panel under the leadership of CAAIST, which is led by DFG. Evaluations will be conducted following years one, two and five; and on an "as needed" basis after that.

Implementation Table
(see separate file)

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IX: GLOSSARY

Accidental introduction: an introduction of nonindigenous aquatic species that occurs as the result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast water or in water used to transport fish, mollusks, or crustaceans for aquaculture or other purposes.
Aquatic invasive species: a plant or animal species that threatens the diversity or abundance of native species, the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters. (Note: for the purposes of State management plans, reference to an aquatic invasive species implies that the species is nonindigenous.)
Biocontrol: The use of living organisms, such as predators, parasites, and pathogens, to control pest insects, weeds, or diseases.
Ballast water: any water and associated sediments used onboard a ship to increase the draft, change the trim, regulate the stability, or maintain the stress loads of the vessel.
Control: eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.
Cryptogenic species: an organism of unknown origin; may be introduced or native.
Ecological integrity: the extent to which an ecosystem has been altered by human behavior; an ecosystem with minimal impact from human activity has a high level of integrity; an ecosystem that has been substantially altered by human activity has a low level of integrity.
Eradicate: the act or process of eliminating an aquatic invasive species.
Established: An introduced organism with a permanent population(s), i.e., one that has the ability to reproduce and is not likely to be eliminated by humans or natural causes.
Exotic: (same as nonindigenous and non-native) any species or other variable biological material that enters an ecosystem beyond its historic range, including such organisms transferred from one country to another.
Fouling: entanglement, clogging, or obstruction by an undesired organism often resulting in diminished functioning of ships, intake pipes, and other submerged equipment or machinery.
Incipient infestation: A small colony of an aquatic invasive species that has spread to a new area.
Intentional introduction: all or part of the process by which a nonindigenous species is purposefully introduced into a new area.
Introduction: The intentional or unintentional escape, release, dissemination, or placement of a species into a California ecosystem as a result of human activity.
Invasive species: organisms that may threaten the diversity or abundance of native species or the ecological integrity and stability, and/or uses, of infested waters. Invasive species may also negatively affect human health and/or the economy.
Native species: A species within its natural range or natural zone of dispersal, i.e., within the range it would or could occupy without direct or indirect introduction and/or care by humans. Existing within a historical ecological range, usually within a balanced system of coevolved organisms.
Non-native or Nonindigenous species: any species or other variable biological material that enters an ecosystem beyond its historic geographic range, including such organisms that have been transferred from one country to another.
Pathogen: a microbe or other organism that causes disease.
Pathways: Natural and human connections that allow movement of species or their reproductive propagules from place to place.
Pioneer infestation: see incipient infestation.
Priority species: An aquatic invasive species that is considered to be a significant threat to California waters and is recommended for immediate or continued management action to minimize or eliminate their impact.
Stakeholders: Any and all interested parties.

Watershed: the geographic area that drains to a single water body or hydrographic unit such as a lake, stream reach, or estuary. An entire drainage basin that contains all living and nonliving components.